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For Announcement of Spring Meeting and Coming Meetings of Sections See Section Two of this Number

Contributors and Contributions

J. F. Johnson on Large Steam Turbines

This illuminating review of the characteristics and features of design, construction and operation of large steam-turbine units was presented at a meeting of the Philadelphia Section of the Society. The paper is one of the much-appreciated contributions on the subject of the steam turbine because for one thing it goes frankly into the difficulties which have been experienced in the operation of these large units. From the discussion, one learns that the difficulties are not insurmountable and that they are not such as to stand in the way of the continued use and successful operation for units such as are now used of 30,000 kw. and upward. Mr. Johnson is connected with the Westinghouse Machine Company.

Victor J. Azbe on Refrigeration

This contribution is an abstract of the paper presented by Mr. Azbe at the last Annual Meeting at the Joint Session on Refrigeration held by The American Society of Mechanical Engineers and the American Society of Refrigerating Engineers. Mr. Azbe, besides acting as mechanical engineer for one of the large interests in this country employing refrigerating machinery, has traveled extensively throughout the country inspecting power plants and refrigerating plants. Few have had so favorable an opportunity to observe operating conditions and to report upon them. The paper deals with the conditions prevailing in the majority of ice plants operating under commercial conditions and makes suggestions in regard to increasing the efficiency of their operation.

C. T. Hutchinson on Economical Section of Water Conduit

This paper by Mr. Hutchinson, consulting engineer of New York, deals mathematically with the power-plant problem of determining the economical section of the conduit for supplying water to a power plant. This is the first of the papers to be presented at the next Spring Meeting of the Society to be printed in MECHANICAL ENGINEERING.

Engineering Achievements of Army and Navy

At the last Annual Meeting lectures were given which were later reported in MECHANICAL ENGINEERING upon some of the remarkable engineering accomplishments of the Navy during the war and upon some features of the work of the Ordnance Department of the Army. A short time ago, there was held in Washington, D. C., an exhibit for the benefit of the technical press to illustrate certain of the engineering achievements of the Army. It was the pleasure of one of the editors of MECHANICAL ENGINEERING to attend the exhibit, and the few brief notes published in this number outline some of the things which were exhibited. A second article, by Ensign C. L. McCrea, U. S. N. R. F., tells of the mounting of 7-in. navy guns on caterpillar tractors, an entirely new mount for guns of this size. It was early determined that for submarine protection 5-in. guns mounted on battleships and cruisers would be more effective than 7-in. guns, which therefore released a considerable number of the latter, and effective use was to have been made of them for the campaign which it was supposed would occur this spring, by mounting them for land transportation, as described in this article.

Diesel Engines for Merchant Ships

In the last number of MECHANICAL ENGINEERING were contributions from the San Francisco Section of the Society discussing the features of the fuel problem which proved most vital in the campaign for fuel conservation on the Pacific Coast. The San Francisco Section has done another service by holding a meeting for reviewing the recent developments in the use of Diesel engines on merchant ships on the Pacific Coast, as will be seen from the two brief papers on the subject published in this number.

Properties and Preparation of Glue

Reference has already been made in these columns to the valuable data given in the Bulletins of the Experimental Department, Airplane Engineering Division, U. S. A., which until after the armistice was signed were treated as confidential. Much of this matter has now been released, and we have published in this month's issue data taken from the Bulletin upon the subject of glue and its use—a subject upon which but little has heretofore been generally available.

Lubrication of Air Compressors

This article summarizes a report prepared by the secretary of the Compressed Air Society and issued by the Technical Committee of that society.

THE LARGE STEAM TURBINE

Development of Large Units to Meet Modern Power Requirements—Records of Performance—Notes on Design and Construction

By J. F. Johnson,[1] Pittsburgh, Pa.

The remarkable growth of the electric-power industry during recent years has been paralleled by an equally remarkable development of steam-turbine-driven generating units. So rapid has been this development that frequently before the first machine of a new design was completed another of materially greater capacity and higher efficiency was being designed.

While machines of 15,000 kw. capacity were put into operation as early as 1908, their use did not become general until 1913; and yet today nearly every one of what may be called our large generating stations has at least one unit of 30,000 kw. capacity or larger.

Has this growth been natural and healthy, or has it been forced? Will the tendency be toward larger units or will a reversion to smaller sizes occur? If such reversion occurs, will it be the result of faulty engineering, born of overconfidence on the part of the builders or users of the apparatus, or because units of 30,000 kw. and larger are too large for the present and immediate future requirements of our large power-generating stations?

In our chief industrial centers, the electric-power industry has attained its broadest development. Here the appeal of "Do It Electrically" has gained a universal response. As a result power consumption per unit of area has reached high values and this has encouraged the formation of large public-service companies, both by means of development, and by means of consolidation of smaller ones. Moreover, a careful analysis of the present applications of electric power will not disclose a likelihood of serious decrease in any of them. On the other hand, there are many applications in which marked future growth seems certain. Important among these are the separation and purification of metals, the use of the electric furnace in metallurgy, and the electrification of our present steam railroads. There can be no doubt that the electric power industry is today only in the midst of a rapid and healthy growth.

In designing machines of large capacity, the selection of the number and sizes of units in a station of given capacity is most important since this selection materially affects the total cost of power generated. If the sizes of units be too small, the cost per kilowatt of the completed station will be greater, the maintenance and operating expenses higher, the efficiency lower, and the reliability at least no greater than if the proper sizes are used. On the other hand, if the units be too large, the cost per kilowatt installed may be too great because of the greater reserve capacity required, and the efficiency may even be lower by reason of the units operating at loads too far below their points of best efficiency.

Take for example a district with a maximum peak requirement of 600,000 kw. To insure proper reliability it is decided to generate in three stations of approximately equal sizes. Assume that these stations will normally always operate in parallel and that there will be one spare unit for each five in service during the peak. If 20,000-kw. units were used, there would be 30 operating and six spares, a total of 36 units, 12 in each station. If 30,000-kw. units were used, there would be 20 operating and four spares, a total of 24 units, eight in each station. If 40,000-kw. units were used, there would be 15 operating and three spares, a total of 18 units, six in each station. If 60,000-kw. units were used, there would be ten operating and two spares, a total of 12, four in each station.

If, in order to remove from this consideration of ideal size of units conditions imposed by the design of the apparatus, it is assumed that, irrespective of the size, the reliability, efficiency, and purchase price per kilowatt will be the same, then the best results are to be expected with either the 40,000- or 60,000-kw. sizes, because the installation and operating costs would be less per kw.; the efficiency higher because of the higher efficiency of the larger units; and the reliability greater because of the smaller number of operations of starting and stopping and cutting in and out of service of units necessary.

In so far as conditions affected by the design of units are concerned, it is quite generally appreciated that in sizes up to at least 30,000 kw. capacity higher efficiency at the same cost per kilowatt is obtainable purely by reason of the larger size, and a still higher efficiency for a slight increase in cost per kilowatt; and it has been quite conclusively demonstrated that as high a degree of reliability is obtainable in these larger units as in the smaller ones. Fig. 1 shows the approximate relative steam-consumption rate of units varying from 5,000 kw. to 40,000 kw., but all designed for the same cost per kilowatt.

Appreciating the need of generating units of large capacities in the future growth of the electric power industry, the engineering staff with which the writer is associated took up several years ago the work of designing such machines, assured themselves of their feasibility, and advocated their use. A number of them have been in operation several years, and their expected excellence as to reliability and efficiency has been fully verified.

Record of Performance of Large Turbine Units

Up to the present time 14 units have been sold, varying in capacity from 30,000 to 70,000 kw. maximum. Of these 10 have been placed in service and seven of them have been in service for periods varying from 1 to 5 years. The record of these machines in operation should emphatically remove any doubt as to the commercial possibility of units of large capacity, and satisfactorily prove that at least within limits not yet reached, increase in size need not impair reliability, and may improve efficiency.

The first three of these units, which are exact duplicates of each other, were sold to the Interborough Rapid Transit Company of New York. They are of the two-cylinder, cross-compound, pure reaction type; 30,000 kw. maximum rating with point of highest efficiency at 25,000 kw., operating with 205 lb. steam pressure, 120 deg. fahr. superheat and 29 in. of vacuum referred to 30 in. The high-pressure cylinder operates at 1500 r.p.m., and the low-pressure at 750 r.p.m.

The first one was put in service December 30, 1914, the second in February and the third in August, 1915. Very elaborate and exact steam-consumption tests were conducted by the purchaser on the first of these units.[1]

These units have been operating on an average of from 16 to 20 hours per day, on fluctuating railway loads of from 10,000 to 30,000 kw. With the first and third no trouble has been experienced and they have been ready at all times for any service within their designed capacity except during periods of inspection. In the case of the second the labyrinth packing on the balance pistons of the high-pressure element has failed three times, requiring renewal of some parts. The cause of these failures was supposed to have been improper adjustment, but investigations following the third failure indicated excessive lost motion in the thrust bearing and heavy distortional stresses due

[1] Engr. Turbine Dept., Westinghouse Elec. & Mfg. Co., Mch. Works. Mem.Am.Soc.M.E.

Abstract of paper presented at a meeting of the Philadelphia Section of The American Society of Mechanical Engineers, November 26, 1918.

[1] See paper by Messrs. H. G. Stott and W. S. Finlay, Jr., presented at May 1916 meeting of New York Section of the A.S.M.E.

to rigid bracing of the steam pipe near the turbine as the probable causes.

The fourth unit, placed in operation in the Northwest Station of Commonwealth Edison Company, Chicago, in September 1917, consists of a tandem-compound, pure reaction turbine, direct-connected to a single generator. It has a rating of 30,000 kw. with

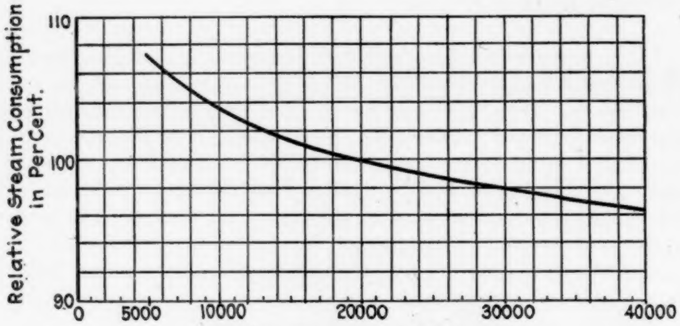

FIG. 1 RELATIVE STEAM CONSUMPTION FOR UNITS OF VARIOUS CAPACITIES DESIGNED FOR EQUAL COST PER KILOWATT

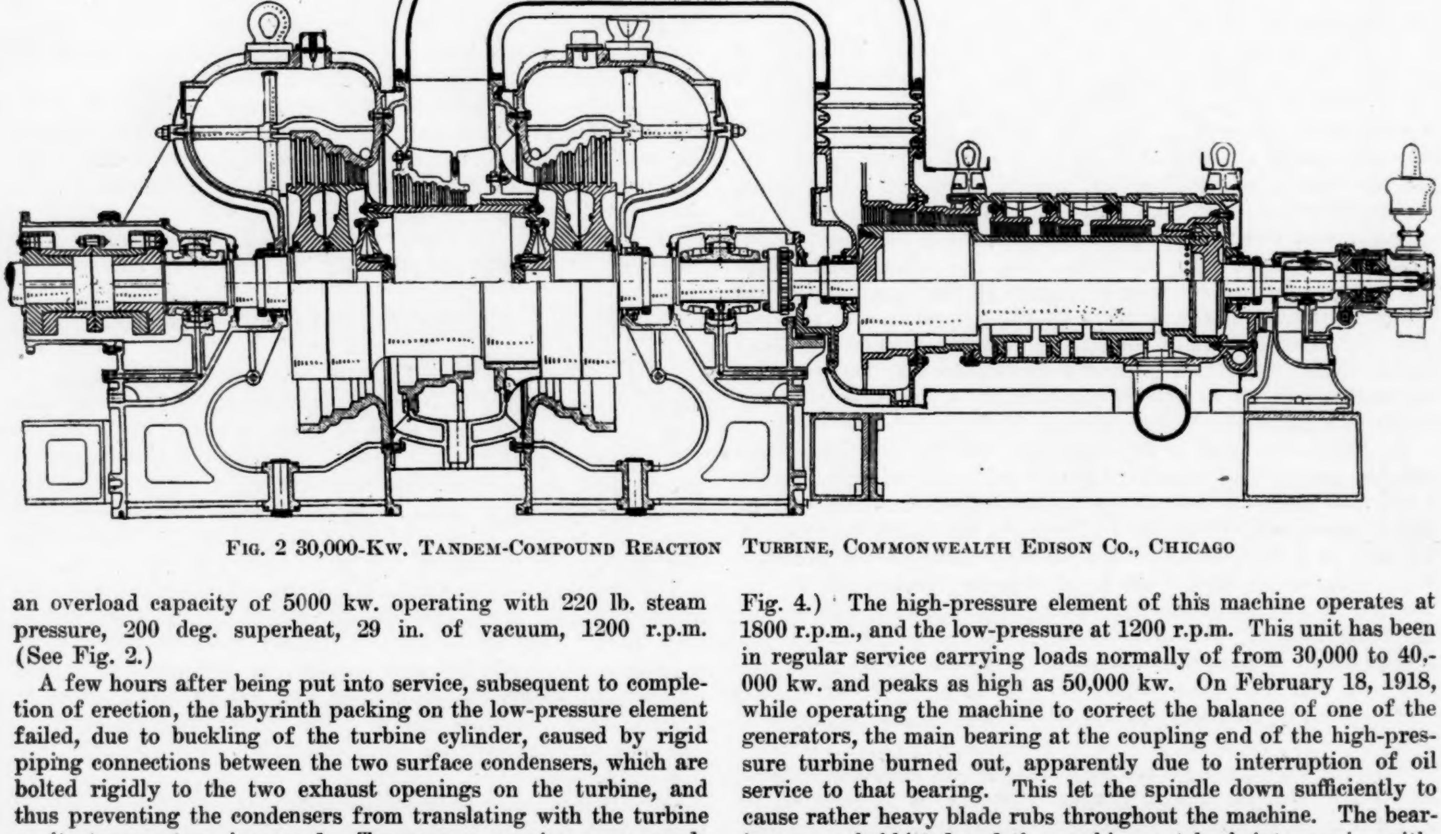

FIG. 2 30,000-KW. TANDEM-COMPOUND REACTION TURBINE, COMMONWEALTH EDISON CO., CHICAGO

an overload capacity of 5000 kw. operating with 220 lb. steam pressure, 200 deg. superheat, 29 in. of vacuum, 1200 r.p.m. (See Fig. 2.)

A few hours after being put into service, subsequent to completion of erection, the labyrinth packing on the low-pressure element failed, due to buckling of the turbine cylinder, caused by rigid piping connections between the two surface condensers, which are bolted rigidly to the two exhaust openings on the turbine, and thus preventing the condensers from translating with the turbine as its temperature increased. Temporary repairs were made locally and the unit put in service in about four weeks. It has been operating almost continuously since carrying loads as high as 40,000 kw. In one instance it was kept on the line for 71 days and then taken off only in order to clean the condenser. Material for making permanent repairs to the labyrinth packing was shipped to the station within a few months after the accident, but the purchaser has not yet given permission to take the unit out of service long enough to install it.

The fifth unit, a 30,000-kw. pure reaction single-cylinder machine, operating on 200 lb. steam pressure, 100 deg. superheat, 29 in. vacuum, was placed in operation in the Gold Street Station of the Edison Electric Illuminating Company of Brooklyn, in October, 1917. Owing to congestion in the shops and urgency of shipment, this turbine was not operated prior to shipment. The overspeed test was made after installation. No correction of balance was necessary, and with the exception of a few leaks in the oiling system, and the breaking of a defective gear on the oil-pump drive, no trouble of any sort has been experienced. It has been available for service at all times and has been operating approximately continuously, except over Sundays and when necessary to clean the condensers, at average loads of approximately 23,000 kw., and peak loads as high as 32,000 kw. (See Fig. 3.)

The sixth unit, placed in service in December, 1917, in the Kent Avenue Station of Brooklyn Rapid Transit Company, is a duplicate of the fifth machine. Immediately after its installation a rebalancing of both turbine and generator rotors was necessary. After having been in service approximately 10 months, the thrust bearing overheated and wiped some, but did not damage any other part of the machine. When opened for inspection it was found that the labyrinth packing strips, which were made of an aluminum alloy, were considerably corroded by the action of strong alkalies used at this plant for treating feedwater; and two rows of blading in the high-pressure portion of the machine were found to have been damaged at some previous time, probably by foreign matter or a defective blade.

The seventh unit is a 40,000-kw., 60-cycle, cross-compound machine, installed in the Brunot's Island Station of the Duquesne Light Company, and placed in service in December, 1917. (See Fig. 4.) The high-pressure element of this machine operates at 1800 r.p.m., and the low-pressure at 1200 r.p.m. This unit has been in regular service carrying loads normally of from 30,000 to 40,000 kw. and peaks as high as 50,000 kw. On February 18, 1918, while operating the machine to correct the balance of one of the generators, the main bearing at the coupling end of the high-pressure turbine burned out, apparently due to interruption of oil service to that bearing. This let the spindle down sufficiently to cause rather heavy blade rubs throughout the machine. The bearing was rebabbitted and the machine put back into service without any other work being done except rechecking the clearances and placing a balance weight on the spindle to correct for the weight rubbed off the blades.

In July the generator was damaged by electrical trouble, and while this repair was being made, both elements of the turbine were dismantled. The high-pressure rotor was returned to the shops and the damaged blading replaced and rebalanced. New blading was also installed in the stator to restore original clearances and original efficiencies. Inspection of the low-pressure element revealed several broken blades which were defective and had slightly damaged the rest of the blading in their rows, requiring replacement of approximately 1½ rows of blading on each end of the machine.

The eighth unit, practically a duplicate of the seventh, rated at 45,000 kw. maximum, was placed in service for the Narragansett Electric Light Company in Providence in January, 1918. In

placing this machine in service the labyrinth packing on the high-pressure was damaged, due to improper adjustment, which necessitated temporary repairs, keeping the machine out of service until about March. Since then no trouble has been experienced except some distortion of the couplings caused by a series of violent short-circuits. Permanent repairs to the labyrinth packing have been made and new coupling parts are to be installed in the near future. In the meantime the old parts are operating satisfactorily without any evidence of distress. This machine operates on loads as low as 5,000 kw., and has carried a peak load of 50,000 kw. for periods of from four to five minutes.

The ninth unit is a 70,000-kw., three-cylinder, cross-compound, 25-cycle machine, installed for the Interborough Rapid Transit Company in New York. The one low-pressure element was placed in service April 18, 1918, operating on high-pressure steam. The high-pressure element was placed in service August 21, operating in connection with the low-pressure already installed, and the second low-pressure element was placed in service October 9.

Some intermittent vibration trouble appeared on the first low-pressure machine, the cause for which was found to be lack of sufficient clearance on one of the spindle rings, causing distortion during expansion. After this was corrected no further trouble was experienced except the breaking of a few defective blades on the intermediate stage of the second low-pressure element. This unit is equipped with a controlling mechanism for cutting any element out of service, either automatically or manually, without disturbing the other two. These features have been given a thorough tryout, and have verified all expectations as to flexibility. In regular service it has carried loads as high as 55,000 kw. with swings up to 61,000 kw. This turbine is shown in Fig. 5.

While these records do not show perfection in all respects, they do exhibit sufficient evidence to prove that no inherent or basic defects in design or difficulties in construction or operation have been encountered.

With one exception no important part of any one of these units has ever been returned to the works for replacement, alteration, or repair. The high-pressure rotor of the Duquesne Light Company unit was returned to the shops for checking for truth and reblading.

Notes on Design and Construction

The theoretical design of a steam turbine is in itself quite simple. The proper steam path for any assumed rate of steam flow, given the number of stages and areas through each for any assumed blade velocity and ratio of steam velocity to blade velocity, may be determined with the aid of a steam table or sufficiently accurate Mollier diagram.

The successful practical design, however, is quite involved, comprising many problems worthy of the highest engineering skill. Many conflicting factors must be judiciously combined in order to secure the best design and one which will best serve the intended purpose.

In this as in all other arts, experience is the great teacher, and highest success is attained only after years of growth and adherence to the same basic design, the principles of which must be right and therefore susceptible of the highest development.

To begin with, the engineer must have a clear vision of his ideal—his turbine made perfect in every detail. This must be the standard toward which he constantly strives, deviating from it only as compelled to in compromising between conflicting factors. In this ideal *reliability* and *general operative excellence* must stand out as the dominating characteristics, because above all things the machine must be dependable to deliver its rated capacity of kilowatts upon demand; second to this comes *efficiency,* because it must in competition with other units yield a profit for the owner; and third comes *cost,* because the unit must be salable in competition.

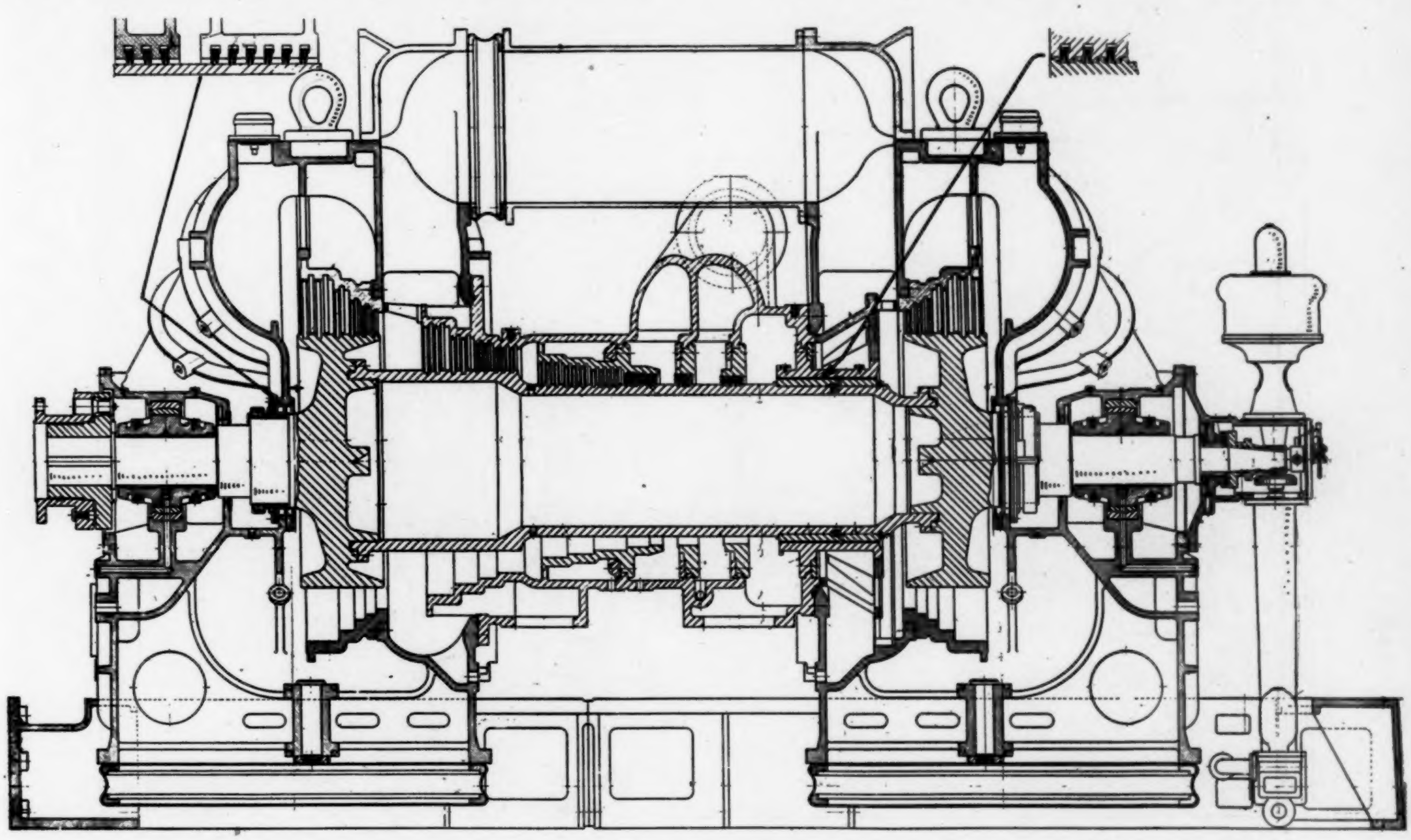

FIG. 3 30,000-KW. SINGLE-CYLINDER REACTION TURBINE, EDISON ELECTRIC ILLUMINATING CO., BROOKLYN

Steam Areas

The first and perhaps greatest single problem is suggested in the theoretical design: it is to provide areas suitable to accommodate the enormous increase in volume of the steam while passing through the turbine. Assume steam supplied at the throttle at 250 lb. gage pressure and 150 deg. superheat. This enters the first stage at a pressure of about 255 lb. absolute and specific volume of 2.28 cu. ft. per lb. (allowing 10 lb. drop through the throttle and inlet valves). It leaves the last stage at 380 cu. ft.

per lb. when 28½ in. is maintained by the condenser, and 550 cu. ft. per lb. when 29 in. is maintained; that is, the volume when exhausting to 28½ in. vacuum is 166½ times, and when exhausting to 29 in. is 241 times as large as it is at the entrance. This means that if the rate of steam flow is such as to require an 18-in. steam inlet pipe; and if its velocity were maintained the same through the exhaust as through the inlet pipe then, when expanding to 28½ in. vacuum, the exhaust opening would have to be 19 ft. 4 in. in diameter, and when expanding to 29 in. vacuum 23 ft. 4 in. in diameter. If, further, the mean diameter and exit angle of all the rows of blading be the same and the ratio of blade speed to steam speed be the same in each, thereby keeping the theoretical efficiency of all stages equal, and if these blade and steam speeds be so chosen as to fix the height of blades in the first stage at one inch, the last row would have to be approximately 13 ft. 10½ in. if designed for 28½ in. vacuum, and 20 ft. 1 in. if designed for 29 in. vacuum.

The impracticability of adhering to such proportions in actual designs is obvious.

Rotor Speed and Blade Proportions

Here is where the combining of conflicting factors begins. In the first stages the areas and blade heights should be kept large in order to reduce the losses, and in the low-pressure stages they must be sacrificed on account of practicable limits of mechanical design. In single-cylinder machines where the blading is all on the same spindle, the problem becomes doubly difficult.

The first determination is that of rotative speed which is usually not difficult to make since the frequency of the generator restricts the permissible speeds to a few and these are rather widely separated. The limiting capacities at the various permissible rotative speeds for which generators can be built must also be considered, although at the present time the practicable limits of turbines and generators are reached at approximately the same capacities except in the case of single-phase generators. With these the limiting capacities are very much less than with polyphase generators.

The chief factor in the selection of the rotative speed is the design of the last row of blades with reference to height, diameter and exit angle, because this is the most important stage in the entire turbine. In it the mechanical stresses and fatiguing effect of vibration, the B.t.u. drop, and physical dimensions, are all greatest. Consequently, upon it depends largely the reliability, efficiency, and cost of the unit.

Here must be considered the alternatives of a higher rotative speed with the low-pressure stage made multiflow as against a slower rotative speed and single-flow construction.

The length of blades must not be excessive with reference to the diameter, not only because of the higher stresses in the blades and rotor, but also because the difference in velocity of the blades at their tips and at their roots, as well as the difference in blade spacing, will, if too great, materially impair the efficiency.

On the other hand, if the area through the blades be restricted, the steam velocity will become too high and the bearing losses too great. If this restriction is carried to the extreme, the steam in passing through the last row of blades may reach its critical velocity without expanding entirely down to the condenser pressure, in which event the remainder of the expansion takes place in the form of an explosion upon leaving the blade passages, and from it only a small percentage of the energy is recovered.

In order, therefore, to secure the most satisfactory design for the last stages, and to permit the stresses or physical dimensions with the ever-present cost from becoming prohibitive, several compromise features should be employed.

The first of these consists of increasing the rotor diameter and blade heights, until the safe limit of stress is reached, keeping the blade height within approximately one-fourth of the rotor diameter as a limit of good practice. The materials of which the rotor and blades are made will of course determine the safe stres-

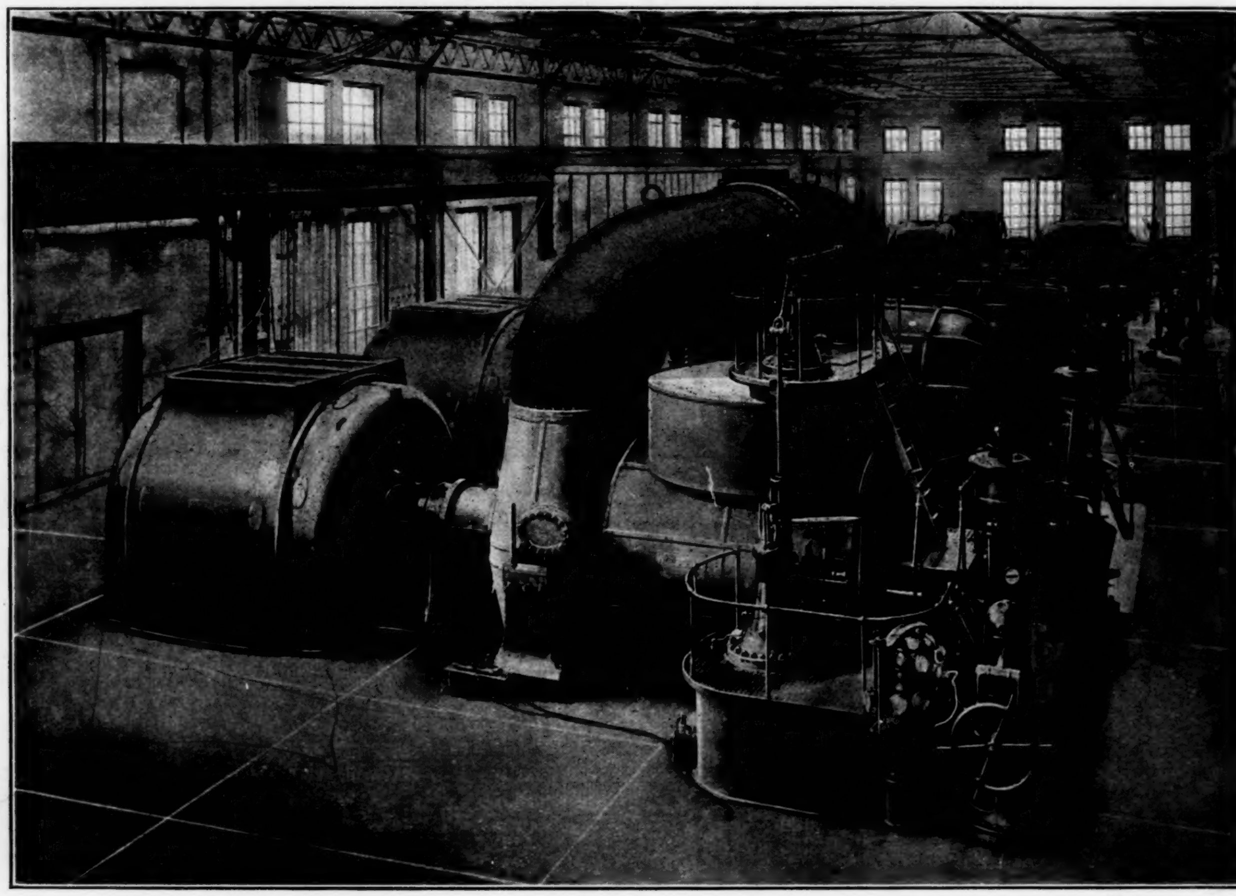

FIG. 4 40,000-KW. CROSS-COMPOUND TURBINE AND GENERATOR, DUQUESNE LIGHT CO. BRUNOT'S ISLAND STATION

ses, and on account of the great import of safety and reliability in these parts, only good quality of plain or 5 per cent nickel low-carbon steels should be used. These are commercially common materials, uniform in quality and do not require sensitive heat treatments.

For rotors cast or forged, steel having a tensile strength of 70,000 lb., true elastic limit of 28,000 to 30,000 lb. and elongation of 18 per cent. in 2 in. may be stressed to 20,000 lb. per sq. in., and for blades, 5 per cent nickel steel having a tensile strength of 85,000 lb., and true elastic limit of 35,000 lb., may be stressed to 25,000 lb., both at 20 per cent overspeed. The stresses at normal operating speed will therefore be 13,900 and 17,350 lb., respectively, and the factor of safety against rupture approximately five.

Increasing the diameter not only permits increasing the blade height, but also the steam speed without materially affecting the efficiency, by reason of the increase in blade speed. There is, however, a slight falling off in efficiency with the higher speeds even though the ratio of blade speed to steam speed be kept practically constant, because the actual velocity of the steam with reference to the blade being greater, the frictional losses will be greater.

The second compromise consists of increasing the steam-passage area through the blades by changing the blade shape. This change increases the angle between the direction of steam flow from the blade and the direction of the blade, and a slight impairment of efficiency results. However, this loss is slight compared to the gain from the higher ratio of blade speed to steam speed resulting from the increased area. This practice is standard on practically all condensing machines built for high vacuum.

Multiple Stages

The third compromise consists of permitting the steam speed to increase without a corresponding increase in blade speed, thereby decreasing the ratio of blade speed to steam speed and increasing the leaving losses. This compromise may properly be employed up to the point where the loss of efficiency will justify the increased expense of greater blade areas which may necessitate dropping to a lower rotative speed, or employing multiple stages.

Two or more low-pressure stages in multiple in connection with a single high-pressure stage are used when the required areas cannot be obtained with a single stage at the rotative speed chosen, and when it is more feasible to employ multiple stages than a lower rotative speed. Other considerations favoring multiple stages are reduced physical dimensions of the exhaust chambers, thus simplifying both the ribbing and bracing necessary to maintain the proper rigidity, and eliminating difficulties incident to shipping large units.

The design of the higher stages usually involves only an equitable selection of diameters, blade speeds, and steam speeds. Keeping these low, results in low stresses and high efficiency, but large number of stages and high cost; while keeping them high reduces the length, weight, and cost, but increases the stresses and impairs the efficiency.

If the steam volumes in the first stages are relatively small for the rotative speed employed, as would be occasioned by the use of high steam pressure or low rating, a double velocity-stage impulse element may often be employed to advantage; the advantages secured being reduction of length, increased diameter, reduced pressure and temperature inside the main cylinder, and adaptability for varying overload capacity, but not increased efficiency nor decreased cost.

Rotor Proportions

Having fixed the rotative speed to secure proper design of the low-pressure stages, and the diameters and steam speeds of the high-pressure stages to give the highest economy, the length of the rotor may become excessive, necessitating its division into two parts in order to maintain requisite reliability. These parts may be arranged either in tandem form, driving a single generator, or in cross-compound form, driving two generators. When arranged cross-compound it will often be found advantageous to increase the rotative speed of the high-pressure element, thus gaining reduced physical dimensions, weight, and cost, without sacrifice of efficiency or reliability. The multi-cylinder construction is especially desirable in the employment of high steam pressures and superheats in that the high-pressure turbine structure is small and there is no danger of stress complications resulting from wide temperature differences and no transmission of heat through the cylinder walls from the high-pressure to low-pressure stages. It has a further advantage in these days of increasing steam conditions since a unit may be designed for given steam conditions and later redesigned for materially higher conditions, the redesign being carried out entirely in the high-pressure element.

In units of 60,000 kw. or larger, the three-cylinder cross-compound construction employing one high-pressure and two low-pressure elements possesses the advantages of high efficiency and reliability without employing excessively large structures, and has greater flexibility than is possible with either of the other constructions. This flexibility, enabling the high-pressure element to operate with either low-pressure element, or either of the three elements to operate alone, admirably adapts it for us in systems not yet large enough to permit employing a single unit of such

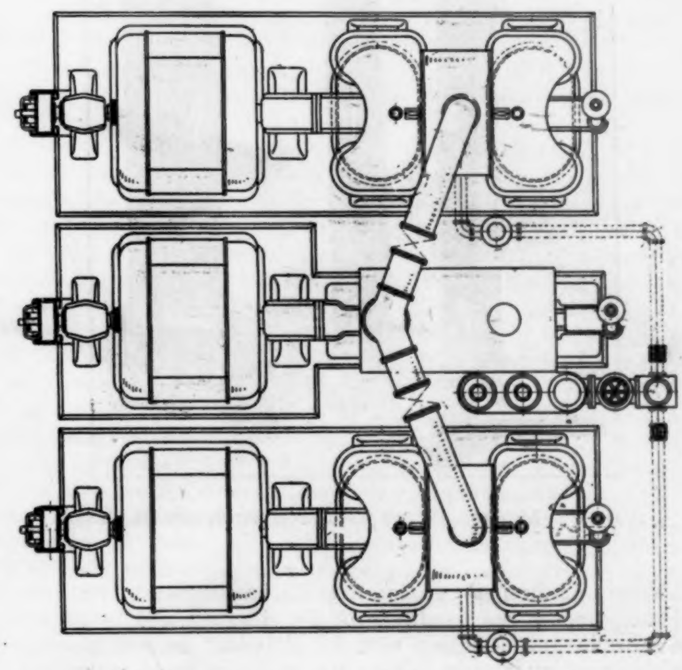

Fig. 5 70,000-Kw. Three-Cylinder Cross-Compound Turbine, Interborough Rapid Transit Co., New York

large capacity. These units may be provided with a control mechanism by means of which either of the elements may be taken out of service either automatically or manually, and the remaining ones carry loads up to the maximum ratings of their generators. The low-pressure elements, when operating on high-pressure steam direct, may be made to carry loads for short periods considerably in excess of the rated capacities of their generators.

Construction Details

Reliability and general operative excellence of a large turbine are largely dependent on the excellence of design of details such as the blading and blade fastenings, provisions for maintenance of clearances and alignment under all possible variations of operating conditions, bearings and oiling system, control mechanism, glands, couplings, and protective devices against overspeeding. The standard practice with regard to these as applied to all large units built by the company with which the writer is connected will be here given.

All low-speed reaction blading in which the stresses do not exceed about 15,000 lb. per sq. in. at 20 per cent overspeed are made of a special bronze composed chiefly of copper and a small percentage of tin and phosphorus. Upon the base of each blade a

foot is forged, and the cross-section of the blade near its base taperingly increased, adding approximately 40 per cent to its area at the point of attachment. These blades are installed in double dovetail grooves by means of specially constructed spacers or interlocking pieces, the spacers being locked in the groove and the feet of the blades locked underneath the spacers. In larger sizes where it becomes difficult to drive up the blades and spacers tight enough to insure perfect fitting between the parts and perfect filling of the grooves, compound side wedges are employed to secure the requisite tightness.

The chief destructive element of all blading is vibration caused by the flow of steam and by vibration of the entire rotor when operated under conditions of defective balance or alignment. The thickening of the blade section near its base serves to very considerably reduce the amplitude of its vibration and to prevent concentration of deflection with its attendant crystallization at the point of attachment, where the ordinary blade is weakest. Blades for higher speeds, in which the stresses may go as high as 25,000 lb. per sq. in., are drop-forged of a very pure electric-furnace iron containing about 5 per cent nickel. They are installed in grooves as shown in Fig. 6.

Fig. 6 Method of Installing High-Speed Blades

The spacers are made integral with the blades, and compound side wedges are used to insure a tight fit at the top of the groove and protect the reduced portion of the blade foot against vibrational stresses. Impulse blading when used is installed in the same manner.

All blades are lashed together to minimize the vibration and maintain uniform spacing. Blades up to 4 in. in height have a single lashing near the top, from 4 in. to 12 in. have two, and those above 12 in. three.

A proper design of the turbine stator so as to insure maintenance of clearances and alignment under all possible variations of operating conditions, such as reduction of steam pressure and total or partial loss of superheat or vacuum, is difficult but essential. In such large structures the amount of expansion and contraction due to temperature changes is considerable, and usually occurs simultaneously with important stress changes caused by varying stage pressures, consequently there is no friction of rest to overcome and a comparatively slight uneven temperature change or unbalanced stress will cause a distortion.

The introduction of high vacuum, bringing with it large diameters in the low-pressure stages and enormous exhaust chambers, necessitates a considerable amount of carefully devised ribbing and bracing in order that the bearings supported in the exhaust chamber structures will under all conditions remain concentric with the stationary blade- or nozzle-carrying elements.

Fig. 7 shows such reinforcing. Cast-in braces when employed are always provided with an open joint which is made up after the rough machining and annealing have been done, thus avoiding all distortional stresses.

The main cylinder castings are made as plain, simple and symmetrical as possible, and the blade-carrying elements are almost invariably cast and finished separately.

The turbine cylinder is always supported on the bedplate by means of chairs or pedestals engaging it as near the center line as possible, and independent of temperature changes caused by varying load or operating conditions. The steam chest and throttle valves are supported on springs so as to move freely with the turbine, consequently the alignment of the main turbine and generator bearings is not affected by these changes.

Practically every turbine element contains three bearings; two to support the rotor, and one to maintain the longitudinal alignment. The supporting bearings consist of heavy cast-iron shells lined with babbitt and split horizontally to facilitate removal. They are so bored that for two-thirds of the circumference the minimum clearance between the bearing and journal is approximately 0.020 in., the journal being normally supported and guided by less than the lower third of the bearing circumference. This large clearance reduces to a minimum the power lost and heat generated in the bearing. The journal speed is not allowed to appreciably exceed 100 ft. per sec. and pressure 100 lb. per sq. in. projected area. A sufficient quantity of oil is supplied through a longitudinal groove in the top of the bearing to provide both lubrication and cooling; consequently no water cooling of the bearings is necessary. The oil pressure normally carried on the bearings is 5 lb. gage, although they will continue to operate satisfactorily as long as the oil supply is sufficient to keep the oil groove filled without any pressure whatever. The bearing is of course self-aligning, being provided with four large spherically machined pads (one each at the top, bottom and either side), which fit a spherical supporting ring in the housing. Underneath each of the four pads several sheet-steel liners of varying exact thicknesses are placed to enable easy and accurate adjustment of alignment. For example, to change the alignment 0.010 in. either vertically or horizontally a 0.010-in. liner is taken from underneath one pad and placed underneath the opposite one.

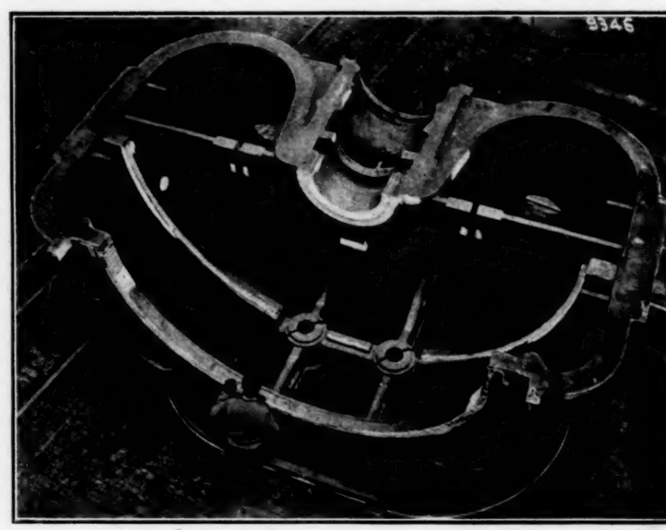

Fig. 7 Ribbing and Bracing of Low-Pressure Chamber

The alignment bearing is of the Kingsbury type, modified in detail design to best serve the requirements of the turbine upon which it is employed. This is believed to be the most perfect form of bearing yet devised for the purpose.

The oil-circulating and cooling system maintains an ample supply of oil at approximately 60 lb. pressure for operating the

governor-controlled valve mechanism, in addition to supplying all bearings at approximately 5 lb. pressure. It is designed with special reference to positive circulation, effective cooling, straining, and settling for separation of foreign matter or impurities, accessibility for thorough cleaning and longevity of the lubricating qualities of the oil. It consists of a cooler, strainer box, settling and separating reservoir, direct-driven pump, and a separate steam-driven auxiliary pump, together with the necessary piping. It ordinarily has a capacity of approximately 1000 gal. The oil flows by gravity from the settling reservoir into the oil pump from which it is delivered under 60 lb. pressure to the valve operating mechanism, thence to the oil cooler, bearings, strainers, and back to the reservoir. A spring-loaded valve located close to the valve-operating cylinder by-passes the surplus high-pressure oil direct to the oil cooler. Units in which a considerably greater quantity of oil is required for lubrication than for operating the valve gear are provided with double pressure pumps to reduce the power required, and the stress on the oil. Under normal operating conditions the maximum temperature of the oil is from 140 deg. to 150 deg. fahr.

The oil cooler is built along the lines of an ordinary surface condenser, and employs regular straight condenser tubes. Every part, including the inside and outside surfaces of the tubes, is readily accessible for thorough cleaning so that the original efficiency of the cooler may be restored at every cleaning. The cooling water makes a sufficient number of passes to raise its temperature close to that of the oil so as to decrease the quantity required.

The strainer box contains three strainers of different meshes which may be removed and cleaned while the unit is in service. If they are allowed to become choked up, the oil will overflow them without interrupting the circulation.

The reservoir is designed to cause impurities and foreign matter to settle to the bottom from whence they cannot get into the oil pump suction, but may be drawn off either manually or automatically to a filtration system.

The oil pump is of the reciprocating-plunger type, direct-driven from the main governor spindle, and is accessible for inspection or repairs without complete removal from the turbine.

Since constant voltage and frequency are insisted upon by public-service companies, good governing of a turbine unit becomes important. The governing mechanism must be extremely sensitive, positive, and quick to adjust itself to small or large changes in load and at the same time rugged, reliable, and unaffected by such variations as occur in ordinary wear and care. For these reasons the following several features of design are employed.

On account of the power required to operate the large valves, some form of fluid pressure relay mechanism is necessary. For this the regular turbine lubricating oil under suitable pressure has proven most satisfactory.

The governor, which is of the flyball type, is made very large and powerful so that it can control the oil relay valve with ease and accuracy. It has a minimum number of moving parts and is made as frictionless as possible by the employment of hardened knife-edge bearings in all connections between the weights and clutch. It is driven from the main turbine rotor through worm and wheel gears at a speed of approximately 300 r.p.m.

Unavoidable inaccuracies in machining of the oil relay control valve, friction and lost motion in the governor and valve linkage, and inertia of the operating fluid are the chief obstacles to good regulation, since the speed must change sufficiently to move the governor weights far enough to overcome all these before there will be any response from the valves, and when they do move they will probably overtravel. These difficulties have been overcome by giving the linkage, adjacent to the governor, a small positive oscillating motion, sufficient to overcome any reasonable lost motion and inaccuracy of the relay control valve, and still cause a very slight oscillation of the main inlet valves. The oil relay control valve and high-pressure-oil by-pass valve are placed as close to the operating cylinder as possible, and a positive or constant-volume oil pump is used. The oil flow is therefore continuous in nearly all of the piping to and from the oil-operating cylinder. Consequently the slightest change in speed will be quickly responded to by a proper change in steam flow.

To prevent leakage of steam or air where the rotor shaft passes through the casing, combination labyrinth and water glands are used. These constitute an ideal sealing arrangement. They are absolutely tight and permit no leakage of steam, vapor, or water into the engine room. They require no adjustments for varying load conditions, and do not depend upon the operation of any automatic devices. There is no mechanical contact between stationary and rotating parts, and therefore no wear. They are extremely simple in design, require no special attention, and are as durable as any other part of the machine.

The simple water gland being ill adapted for operation against high pressures or at speeds very much less than normal, the labyrinth is added to enable establishing a vacuum before starting up, and also to reduce the pressure on the water gland when the pressure against which the gland must seal is high. The operation is very simple. In starting up, high-pressure steam is turned on the labyrinth glands. When about three-fourths speed is reached, the water is turned on and the steam off.

The coupling between the turbine and generator is of a flexible-pin type, and has important advantages over the solid-claw type which it replaced. Sufficient elasticity is provided in the pins to distribute the shocks produced by heavy short-circuits and both the pins and bushings are renewable in case excessive wear takes place.

Ratchet teeth are machined into the circumference of the coupling flange, in connection with which a barring-over device is employed to turn the rotor for inspection or for connecting or disconnecting the two halves of the coupling.

In order to secure the maximum protection against overspeeding, all the steam entering the turbine is made to pass through the primary governor-controlled inlet valve; consequently, if this one valve is kept in proper operating condition it is impossible for the speed to get beyond the control of the governor, regardless of whether or not the overload valves leak or stick. Should either the governor or primary inlet valve become inoperative, a small but powerful overspeed stop mechanism installed in the end of the rotor shaft will come into operation at approximately 10 per cent overspeed, and release the pressure on one side of two small steam pistons which normally have full steam pressure on both sides of them. The resulting movement of one of these pistons will release the main spring on the main throttle valve, causing it to close quickly and the other will admit high-pressure oil to the valve operating cylinder, and close if possible the primary inlet valve.

Reports of several disastrous explosions of aluminum dust in manufacturing establishments induced the Bureau of Mines to investigate the physical and chemical properties of the dust with special regard to inflammability and to the problem of extinguishing fires and of minimizing the force of explosions once started. The results of this investigation together with a review of the literature on the subject are published in the Bureau's Technical Paper 152.

It is reported that aluminum dust burns quietly when in a pile, but if this pile be disturbed in such a manner as to raise a cloud of the dust into the air, the burning takes place with explosive violence. Also, that if a dust cloud already formed having a density within the explosive limits be ignited, a violent explosion results. Moisture is said to be most dangerous if the dust has become heated; hence, as the dust is hygroscopic, a proper system of ventilation is strongly recommended as a precautionary measure. It is equally pointed out that if, when the dust starts to burn from whatever cause, water be added to the mass, hydrogen will be liberated and a terrific explosion result. In one case on record a violent explosion resulted from pouring molten aluminum through a screen into a bucket of water.

The tests did not show the exact conditions under which ignition of the aluminum dust is obtained, but it was concluded that it may ignite at temperatures even lower than those necessary for the ignition of 200-mesh standard Pittsburgh coal dust.

Refrigerating Plant Efficiency

By VICTOR J. AZBE,[1] ST. LOUIS, MO.

THE cost of ice and of refrigeration is a composite figure of many different expenses coming under the heads of manufacturing, selling and general expenses. The cost of fuel is usually the largest item, and it may easily represent the difference between profit and loss.

During the last two years the cost of fuel per ton of ice has doubled, and many plants are now paying $1.50 to $2.00 per ton of ice for fuel alone. In spite of these conditions the majority of refrigerating plants are very wasteful of fuel as a result of improper design, run-down equipment or poor operation. While the possible savings are enormous and can usually be secured with little effort and slight expenditure, the necessity for improving equipment and operating conditions is not realized in the majority of plants.

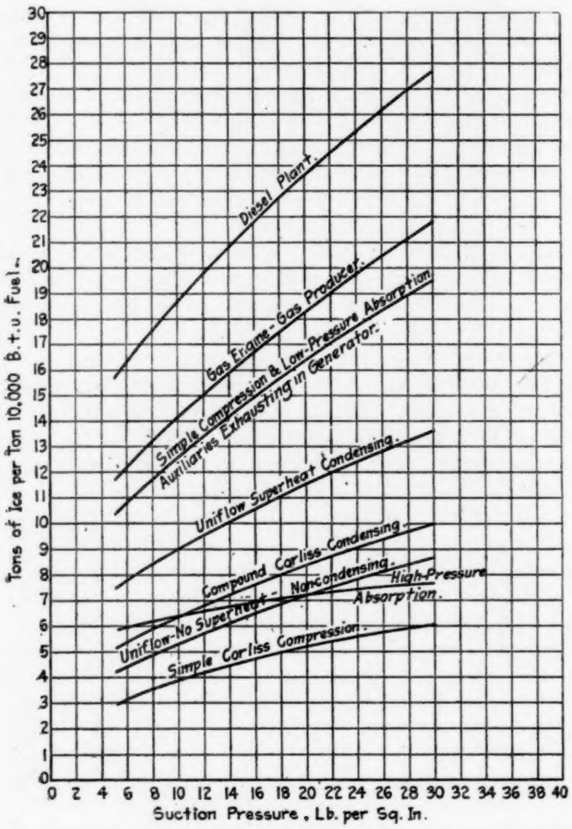

FIG. 1 RELATIVE EFFICIENCY OF VARIOUS ICE-PLANT INSTALLATIONS

It should be the aim to improve the economy of the plants from year to year by making necessary improvements to reduce costs of fuel and labor. Fuel cost, while most important, is not all-important, however, and there are ice plants having a very high fuel economy that are losing money. A high efficiency must be maintained generally in the design of the plant, in its load factor and in its labor and sales organization. There are far more plants making on the average, per year, 1.5 to 2.5 tons of ice per ton of fuel than plants making 5 tons, having simple non-condensing plants in mind.

In this paper the writer expresses himself frequently in terms of tons of ice per ton of 10,000 B.t.u. fuel, to equalize the value of the various fuels (semi-bituminous, bituminous, lignite, oil, etc.), since by a simple recalculation it places them on a common basis.

[1] Consulting Engineer, St. Louis, Mo. Assoc.-Mem.Am.Soc.M.E.

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As the load factor of most refrigerating plants varies greatly, the boiler installation should be such as to give flexibility of operation. In small plants arrangements should be made to reduce the grate surface during the winter periods. Each boiler must be equipped with a draft gage, and the draft should be maintained at the minimum and varied with the load. The boiler setting should be high, even with return tubular boilers, with a space of from 4 to 5 ft. between grate and boiler shell, and the combustion chamber should be so arranged that the benefit of this increased space is obtained. Gases tend to take the shortest path, and with most of the combustion-chamber space devoid of drop walls there will be circulation of the gases and many eddy currents or dead spaces.

Any fuel can be burned if proper provisions are made—shavings as well as oil or semi-bituminous coal. The selection mostly depends upon cost and availability. Lignite, for example, is a most excellent fuel for localities such as Texas. Burning this under return tubular boilers efficiencies were obtained of 63 to 68 per cent.

PRIME MOVERS

The prime mover most generally used in refrigerating plants is the Corliss non-condensing steam engine. Next in order are the compound Corliss, electric motor, oil engine, and uniflow steam engine. If this order were reversed, however, enormous sums of money would be saved to ice manufacturers, for the following reasons:

In selecting the prime mover for an ice plant, the two most important items to consider are efficiency at rated load and efficiency at half load. While the average Corliss non-condensing engine consumes 20 per cent more steam at half load than at full load, the uniflow engine uses only about 8 per cent more. This is of great importance because of the great variations of load factor. Many engines can be found operating at one-eighth cut-off. This is the reason, also, why a steam cylinder should be adapted to the back pressure at which the compressor operates. It is most unwise to have a steam cylinder large enough for economical cut-off at 25 lb. suction pressure when the pressure to be maintained is 15 lb. or less.

Fig. 1 shows the results to be expected from various types of installations. The allowance made for auxiliaries ranges from one-half to one horsepower per ton of ice, depending upon conditions. The condenser pressure was taken at 185 lb. gage, and it was assumed that at the suction pressure given the machine would operate at about full load.

In small plants preference should ordinarily be given to the use of superheated steam, since as high an economy may be obtained from a uniflow non-condensing engine operated with superheated steam as from a compound Corliss condensing engine using saturated steam, and the former equipment is a great deal simpler and necessitates less auxiliary power. Furthermore, the steam-consumption curve is flat and the efficiency of the plant will be maintained during the winter time.

Superheaters can be installed with facility even in existing installations, and since the gain is greater with simple non-condensing engines, uneconomical ice plants will derive great benefit from this procedure.

In order to gain in economy, a simple engine is often made to operate as a condensing engine. As a result, the temperature difference in the cylinder is increased and the cut-off is shortened, which increases the wall area at cut-off as compared to volume. This greatly increases cylinder condensation, which is directly proportional to the temperature difference and the area exposed. It therefore seldom pays to operate such a machine at more than 20 in. of vacuum, and if the plant is to be changed over to condensing operation, it is best to replace the simple Corliss by com-

pound cylinders or by a uniflow engine and leave the rest of the machine intact.

Under proper conditions the ideal and most efficient prime mover for the ice manufacturer is the Diesel oil engine. By "proper conditions" is meant conditions of oil supply and cost, and kind of operating force to be employed. It cannot be overemphasized that with the Diesel engine a high-grade engine-room force must be maintained, and especially during the overhaul period.

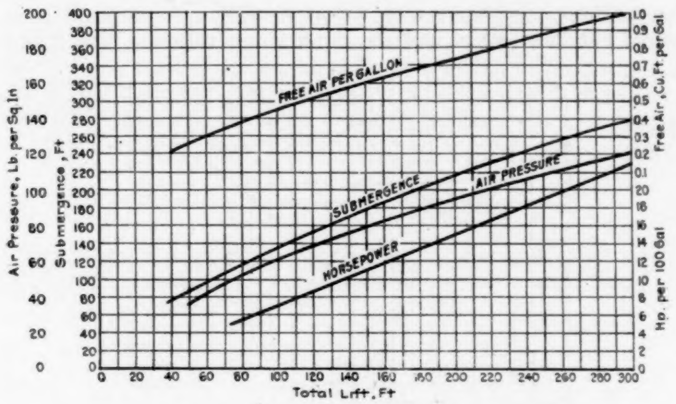


Fig. 2 Standard Air-Lift Performance

If the men in charge are intelligent, the Diesel engine is a very dependable unit. There is a plant in California that produces a ton of ice for 5 gal. of fuel oil, and this not under the best conditions. There are oil-engine installations on record, not necessarily Diesel engines, that have given a ton of ice for less than 10 cents fuel cost, with oil at 2 cents a gallon.

Table 1 gives the average results obtained with Diesel engines over a long period. The net work produced was 1,119,801 kw-hr. The auxiliary power represented the power required for injection in the air compressor, and in the water-jacket circulating pumps. The load factor having been highly variable, the results are not quite as good as they otherwise would have been, consequently the figures may be taken as being conservative and dependable.

TABLE 1 DIESEL POWER-PLANT PERFORMANCE

	Total	Per net Kw-hr.
Wages paid	$4545.10	$0.00405
Fuel-oil consumption	3416.49	0.00305
Lubricating oil	466.86	0.00042
Repairs and supplies bought	1116.50	0.00100
Repairs and supplies, home work	1367.49	0.00122
	$10912.44	$0.00974

Monthly Results

Month	Total Power Generated, Kw-hr.	Total Power for Auxiliaries, Kw-hr.	Net Power Generated, Kw-hr.	Fuel Oil Consumed, Gal.	Cost of Fuel Oil per Gal., Cents	Gal. of Fuel Oil per 100 net Kw-hr.
April	65770	7176	58594	5141	3.63	8.774
May	95270	10712	84558	8142	3.63	9.629
June	119340	13785	105555	10671	3.61	10.109
July	132150	14482	117668	10843	2.9	9.215
August	131540	16275	115265	12593	2.65	10.925
September	114840	12973	101857	10125	2.33	9.94
October	114120	12567	101540	9431	2.31	9.288
November	110160	12737	97423	9459	2.56	9.709
December	113330	12159	101071	9660	3.00	9.558
January	86640	11213	75427	7220	3.13	9.572
February	84490	9489	74991	6993	4.5	9.325
March	128570	14413	114157	11175	4.5	9.789
April	100350	11656	88694	8766	7.0	9.883
May	108950	12871	96079	9232	6.15	9.605
June	176000	19100	156900	15488	6.15	9.871
July	168490	17333	151167	14946	4.25	9.89
August	150890	18652	132238	13569	4.25	10.261
September	90450	11029	79421	8052	4.5	10.138
October	61700	8201	53499	5591	4.87	10.45
November	42540	5867	36673	4076	4.87	11.114

In many localities electric power can be obtained cheaply, and when this is the case electric drive is to be favored. The main advantage of an electric installation is that high efficiency can be obtained through the whole load-factor range and that economy increases as the load factor drops, contrary to the condition in ice plants.

Induction motors are not very well adapted for ice-plant work because of the high speeds required for high efficiencies. Synchronous motors, on the other hand, have characteristics that make them ideal, even for direct connection to refrigerating machines. Their efficiency curve is quite flat and their efficiency is rather high at part loads.

An electrically driven raw-water plant is a great deal simpler than a steam-driven plant. Many factors which influence plant efficiency are eliminated, and consequently the operating man does not have to be as high grade as for the efficient operation of steam plants. Labor cost and repair expenses and the cost of real estate, buildings and machinery are all less. Dependability is also fair, and with proper installation as good as in the case of a steam plant.

Auxiliaries

The curse of most ice plants is the auxiliaries. In many cases the steam consumption of the auxiliaries is as great as that of the engine running the compressor. In a certain ice plant of 100 tons capacity the following auxiliaries were found in operation: Electric-light engine; duplex circulating pump for ammonia condenser; duplex circulating pump for steam condenser; duplex brine pump; duplex boiler-feed pump; ice-hoisting compressor; single-stage single-steam-cylinder deep-well compressor; agitator engine and cooling-tower fan engine.

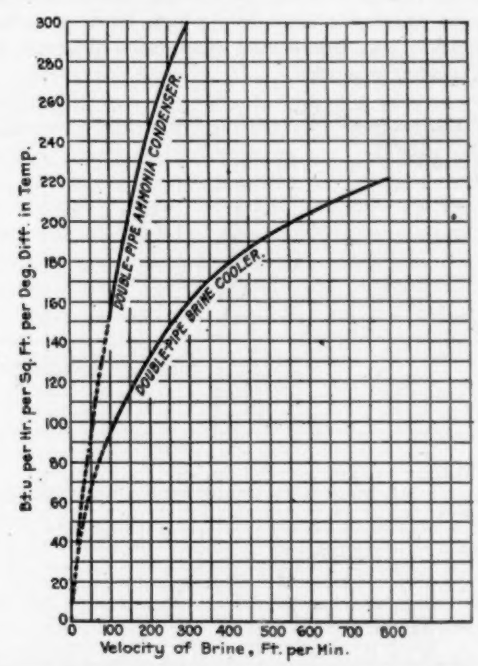


Fig. 3 Heat Transmission with Double-Pipe Brine Coolers and Ammonia Condensers

One of the most uneconomical auxiliaries as usually operated is the air lift. This statement is meant as no reflection upon the air-lift pump as such, but on the way in which it is usually operated. Fig. 2 shows the performance of properly designed air lifts; the efficiency decreases somewhat as the lift increases, but should not be less than 60 to 80 per cent, whereas, actually in some cases it will be found as low as 20 per cent; the trouble is usually too great or too little submergence.

It is seldom advisable to use an air-lift pumping system for

the circulation of water over the steam condenser because of the increased head required. The use of a cooling tower is ordinarily to be preferred, and any water needed for make-up may be taken from the air-lift system and passed over the distilled-water and liquid-ammonia coils, thus cooling the latter below the temperature of the circulating water proper.

For driving auxiliaries, electric current from generators driven by uniflow engines it to be preferred in the majority of installations, and the various units must be selected with a view to obtaining a flat efficiency curve between half and full loads; all motors on the larger units should have variable speed control. Duplex steam pumps or steam-driven deep-well pumps should not be used except possibly as a reserve.

Wet versus Dry Compression

Theoretically, dry compression is inferior to wet, both in regard to refrigeration produced per pound of ammonia circulated and the work required for compression. The difference in economy ranges between 6 and 10 per cent, being greater with low suction pressures and high condenser pressures. Practically, however, dry compression is the more economical; that is, it is capable of producing a greater amount of refrigeration per horsepower expended. The reason for this discrepancy is that when wet gas is admitted into the cylinder the liquid is not suspended, but accumulates at the bottom of the cylinder. There it evaporates so slowly during the compression stroke that the evaporation continues after the discharge valve opens, and often even after it again closes when the piston is upon the return stroke, thus causing a certain amount of reëxpansion loss which tends to reduce compressor capacity. Any liquid that evaporates after the discharge valve opens is utterly wasted.

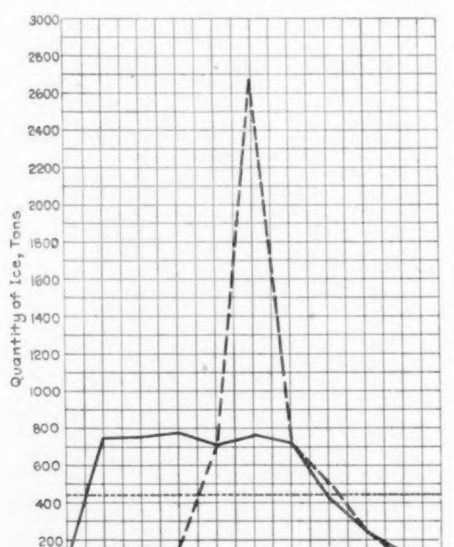


Fig. 4 Effect of Ice Storage on Extreme Load Factor Variations

That there is no benefit in wet compression, as ordinarily practiced, is proven by the compression curve and its relation to the adiabatic and isothermal curves when the machine is operated wet, even to such an extent that the discharge gas leaving the compressor is saturated. In such cases the compression curve will only slightly approach the isothermal, which proves that most of the cooling of the gas by evaporation of the liquid is done after the compression valve opens and thus no benefit accrues from that time on. Liquid and vapor flow separated within the same pipe the same as in the case of saturated steam.

So long as theory indicates an advantage in wet compression, it would seem that further studies and experiments regarding its successful application are justified. Could not some method be devised to atomize the liquid before it reaches the compressing cylinder, or to inject it in the form of a spray during the compression stroke? In any event, precautions must be taken not to introduce liquid into the cylinder in an undivided state, otherwise dangerous accidents are likely to follow.

Wet compression is not only beneficial upon thermodynamic principles, but posesesses a number of other advantages. By its use the temperature difference in the cylinder is reduced by practically two-thirds, which greatly lowers the cylinder superheat and consequently should increase the volumetric efficiency of the machine. Further, with wet compression far less oil is required for lubrication, and the oil does not vaporize, and thus is

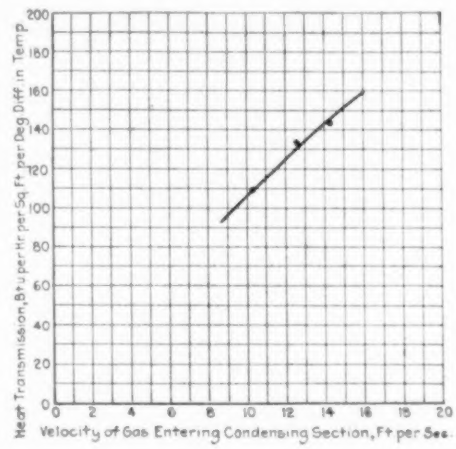


Fig. 5 Effect of Velocity Upon Heat Transmission

easily kept out of the condensing and evaporating coils. Wet compression represents also a saving in ammonia and, in addition, permits a somewhat lower condenser pressure.

Ice Tanks

All the details incidental to the process of ice making should be so regulated as to secure a high rate of heat transmission, coupled with a low temperature difference. The ice tank is a most important member of the ice plant. As far as handling is concerned, great improvement can be made. In a certain plant in St. Louis it was arranged to hoist a row of eighteen 200-lb. blocks by one operation, and the blocks were all thawed and dumped at the same time.

Circulation of the brine in the freezing tank is a very important item. This circulation is at times produced by centrifugal pumps, but ordinarily by propeller agitators. Often these agitators are very inefficient and tend more to churn the brine than to circulate it. It is ordinarily difficult to determine what the circulation in an ice tank is, due to the fact that the speed of the brine varies and its velocity in the lower part of the tank is not the same as in the upper part. About the most practical way is to measure the difference in the height of the brine in the tank on the suction and discharge sides of the bulkhead close to the agitator. With tanks as ordinarily constructed, 1 in. difference of level for each 10 cans of tank length is assumed by the writer as a standard. This method should be fairly accurate since brine flow is the result of difference in level.

In agitating the brine, its leved should never be below the level of the water in the can. Too low a brine level will greatly reduce the capacity of the tank and also the plant efficiency. A wide, shallow hole in the top of the block toward the end of the freezing period is always an indication that the can is too full or the brine too low.

Since with long tanks or very strong agitation, considerable brine level difference is produced, in some cases as much as 5 in., it is best to construct long ice tanks with agitators on each end. Brine velocity is helpful in two ways; it increases heat transmission between the brine and the can, and between the evaporating coil and the brine.

The average transmission of heat from the ice in the can to the

brine outside is very poor, only about 2.5 B.t.u. per deg. per hr. per sq. ft., due to the insulating effect of the ice. The thicker the ice, the slower the heat exchange, consequntly tank brine velocity has not nearly so great an effect upon heat transmission on the can side as it has on the coil side. The heat transmission between ammonia and brine through metal is between 10 to 20 B.t.u. per sq. ft. per hr. per deg. This comparatively low figure is primarily due to the superheating of the gas in the coil, which causes one side of the surface to be dry, and secondarily, to the low brine velocity.

Fig. 3 gives York Mfg. Co. curves showing heat transmission with double-pipe brine coolers and ammonia condensers. The curves were extended by dotted lines to show probable transmission at low velocity. These curves purely from their characteristics show the importance of velocity, an item which from the economy standpoint is certainly worthy of very careful investigation.

Ammonia Evaporating Systems

With expansion coils in ice tanks and cold-storage rooms a high heat transmission is very desirable, and it can be obtained

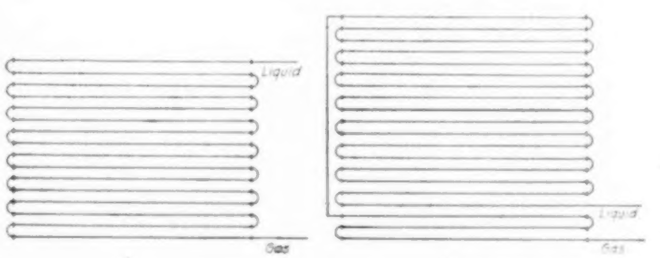


Fig. 6 Ammonia Condenser Types

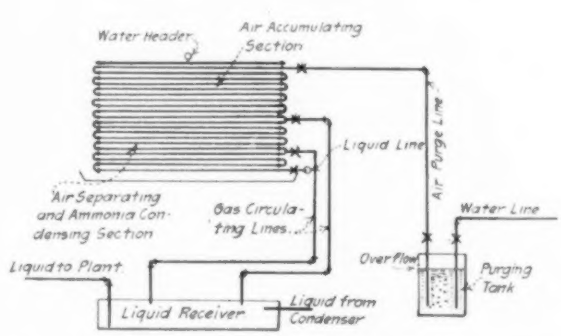


Fig. 7 Non-Condensable Gas-Purging Arrangement

inside of the pipes either by flooding them or using a high gas velocity. The objection to high gas velocity in this connection is pressure drop, which for thermodynamic reasons is rather more important on the evaporating side than on the condensing side. For this reason, the length of the evaporating coil should be limited so that the velocity will never exceed the average figure of 500 ft. per min. Some tank coils are 1500 ft. long and their rather high velocity causes a great pressure drop. For long tanks 2-in. pipe is to be preferred, since the relative surface of 1¼-in. and 2-in. pipe is in the ratio of 1 to 1.5, while the sectional area is in the ratio of 1 to 2.2. Coils should be short so that they are thoroughly effective, and even flooded coils should be as short as possible. The size of suction lines leading to the machines should be governed by permissible gas velocity, friction, and radiation loss.

Ice Plant Load Factor—Ice Storage

Ice storage is profitable in most cases if the storehouse is filled to capacity during the winter and emptied entirely in the summer. The cost of storehouse will be from \$6 to \$12 per ton capacity and the investment will net a substantial return in most cases. The objections to it are the cost of refrigeration for the storage and the increased cost of handling the ice.

As far as plant economy goes, the value of ice storage is due to the equalization of the load factor. That is, the plant can be operated at higher rate during slack seasons and there may not be the necessity for forcing the plant beyond its economical limit in summer. The ice plant and ice storage can be so proportioned that the plant will have a load factor of 80 to 90 per cent, while without ice storage it would be only about 40 per cent, taking the whole year into consideration.

The small ice vault, or daily ice storage, exerts also quite an influence upon plant economy and it cannot be overemphasized that it is advantageous to make it amply large. The idea is to remove ice from tanks as quickly as possible—to use ice tanks for storing ice is a very poor practice.

In Fig. 4 the full line represents the output of ice; the broken line indicates the sale of ice, and the dotted line the proper rate of manufacturing ice. These curves were plotted from the figures actually obtained in a plant. An exact determination of the proper rate of manufacturing ice will permit stopping the plant altogether for a certain time and attending to repairs.

To operate with low suction pressure is far less economical than is indicated by the analysis of compressor performance alone, for the reason that the economy of the engine is also affected by the reduction of load. For this reason, when the condenser pressure drops off during the cold season it is doubly important that the suction pressure be increased and the machine maintained fully loaded. The practice of shutting down one or more ice tanks in winter should be strongly condemned, and no tank should be shut off (except in case of absolute necessity) until the back pressure is at the highest point. Efforts should be made to maintain a back pressure of 30 lb. in winter, and the plant should be designed with that in view. The largest loss is occasioned by the non-adjustment of the various elements to the load factor.

The various rooms or tanks in an ice plant should either be maintained at the same temperature or designed especially for low temperatures. To try to maintain one or two rooms at a low temperature and sacrifice the economy of the whole plant is bad practice, since the suction pressure will always correspond to the lowest temperature. The temperatures should be maintained uniform. When this is not possible, and the difference in the various temperatures is great, then either a multiple effect or a booster compressor should be installed.

Forecoolers and Multiple-Effect Receiver

In a well-designed and efficiently operated ice plant the water to be used for ice making is cooled down to within a few degrees of the coldest circulating water, or ordinarily to a temperature of 70 or 80 deg. fahr. This water then passes into the forecooler to be precooled by ammonia. The heat absorbed by the forecooler can be anywhere up to 30 per cent of the total heat to be extracted in making ice, and the water will be cooled down to about 40 deg. fahr. There are two methods of forecooler refrigeration: by feeding liquid ammonia directly into a coil, or by passing wet return gas from the tank through the water cooler. The first has the advantage that it can be connected to a machine working independently from the freezing tank and thus enable the maintenance of very high suction pressure. The only advantage of passing the suction line through the forecooler is that the expansion valves on the tank can be kept open wider, thus insuring that the freezing coils will work throughout their whole length without danger of getting any liquid to the machine. But this same thing can be accomplished far better by means of liquid separators and it is of greater advantage to use the high suction pressure which is possible with direct feeding.

Refrigerating plants should also be equipped with double-pipe liquid precoolers, cooling the liquid from the temperature of the coldest circulating water down to the temperature corresponding to the highest suction pressure used. In this connection a multiple-effect liquid receiver can also be used, by means of which a greater amount of work can be done at high suction pressure than by the use of the double-pipe cooler alone.

Every refrigerating plant should have an auxiliary compressor for high-pressure work. The size of this compressor may be relatively small for the reason that it will operate at double its rated capacity. One of the most valuable inventions ever made in the refrigerating field is the multiple-effect compressor, which allows gas of higher suction pressure to enter the cylinder after it has been filled with gas of a lower pressure.

Ammonia Condenser

There is no reason for a condenser pressure as high as 200 lb. It always indicates improper conditions, and even in a hot climate the condenser pressure should be below 175 lb.

The cooling tower should cool the water within three degrees of the wet bulb. The relative positions of the condenser and cooling tower should be such that five to six gallons of water can be pumped economically; that is, the pressure due to the head should be less than 15 lb. The condenser should give a heat transmission of at least 150 B.t.u. per sq. ft. per hr. per deg. There should also be sufficient surface, and if the condenser gives better results, less than the specified surface will be needed. In actual practice, results ordinarily are far inferior, due to the water being too warm, to the lack of a sufficient amount of water or of the required condensing surface, to the use of a poor type of condenser, or to the presence of oil or air in the condenser or scale on the outside.

The condenser should be located on the roof of the building, with the cooling tower immediately underneath and so placed that the coils will be parallel with the prevailing direction of the wind in the summer.

The cooling of the water over the condensers is important, not only because it simplifies the action of the cooling tower, but also because it produces a greater temperature difference between the wataer and the ammonia and thus lowers the condenser pressure. Theoretically the ideal arrangement would be for the initial and final temperatures of the water to be the same. This is often realized in winter and is also quite possible in summer in a dry climate with good wind velocity and sufficient condenser surface. It is important to protect atmospheric condensers from the sun.

Condensing coils give a much greater heat transmission per degree difference in temperature than evaporating coils. Better results are obtained with the double-pipe condenser than with the atmospheric because of the higher water velocity of the former. Taking into account the question of initial cost, however, an atmospheric condenser, well exposed, should give, for the same expenditure, as good results as the double-pipe condenser.[1]

TABLE 2 AMMONIA CONDENSER PERFORMANCE

No. of test	1	2	3
Type of condenser	A	B	B
Internal surface per stand, sq. ft	174	222	216
Refrigeration per stand, tons	13.8	5.7	6.5
Surface per ton of refrigeration, sq. ft	12.6	39	33.2
Water on, deg. fahr	73	93	84
Water off last condensing pipe, deg. fahr	98.5	94	90
Water off bottom superheat pipe, deg. fahr	104	94.5	92
Condenser pressure, lb	195	190	210
Condensing temperature, deg. fahr	98	97	103.4
Temperature entering gas, deg. fahr	240	230	245
Temperature leaving liquid, deg. fahr	98	97	100
Logarithmic temp. diff., condensing section, deg. fahr	6.6	3.5	16.5
Logarithmic temp. diff., superheat section, deg. fahr	24	37.5	57
Superheat extracting surface per stand, sq. ft	21.7	22.2	32
Condensing surface per stand, sq. ft	152.3	199.8	184
Entering velocity superheat section, feet per second	8.2	3.3	3.7
Entering velocity condensing section, feet per second	6	2.4	2.7
Mean heat transmission per deg., sq. ft. per hr., B.t.u	155	91.6	26

Table 2 gives the results obtained from tests performed upon condenser sets in actual operation. Type A was a counter-current flooded atmospheric condenser. Type B was a condenser installation consisting of ordinary atmospheric condensers with three superheat pipes at the bottom of each stand. The result in Tests 2 and 3 were obtained with type B. When Test 2 was conducted the condenser surface was very clean both inside and outside and the condenser was free from any non-condensable gases; this probably accounts for the favorable performance secured. The values in Test 3 fairly agree with the ordinary performance of condensers similar to B. The writer possesses data of tests performed upon a dozen of these installations, which show practically the same figures.

Fig. 5 presents the effect on the transmission of heat of the velocity of the water in the pipes of a condenser. The points in the graphs were plotted from values obtained with a 12-pipe condenser of the drip-pipe type.

The velocity of the water in the pipes of a double-pipe condenser may be increased by allowing a greater amount of water to flow through them. The gas velocity increases when the height of the stand is increased by the addition of more pipes. In selecting between high and low condensers, however, other factors must be considered in addition to the water or gas velocity. Generally speaking, high condensers are preferable when the available water is cold.

When a condenser is operated with superheated gas, this should not enter at the top of the stand, as is often done in practice. Type B in Fig. 6 is a convenient form of condenser for use with superheated gas.

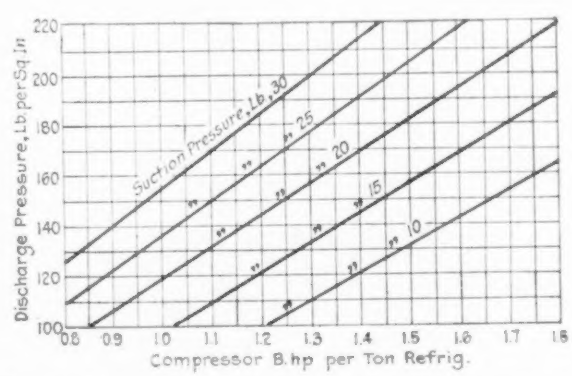


Fig. 8 Compressor Horsepower per Ton Refrigeration

A rather frequent objectionable condition is the presence of air in the condenser. In order to be able to extract it without interfering with the operation of the remainder of the system or losing much ammonia, the condenser must be provided with a suitable purging arrangement, as, for example, the one represented in Fig. 7, which was used with installation B, in Test 2, Table 2.

The presence of air in the condenser often causes the cessation of the flow of the liquid through the pipes and thus seriously impairs the efficient performance of the condenser. The author has had occasion to observe in certain plants he inspected that the condenser pressure dropped 20 to 30 lb. after the air was removed from the system.

Fig. 8 shows distinctly how the compressor horsepower per ton of refrigeration increases with rising condenser pressure, and decreases with rising suction pressure.

Fig. 9 shows how the consumption of condenser water per minute per ton of refrigeration increases as its temperature range over the condenser is decreased, it being assumed that for each ton 350,000 B.t.u. must be removed per 24 hours, inclusive of the heat equivalent of the compressor horsepower.

Cooling Towers and Spray Systems

The economy of a refrigerating plant depends largely upon the temperature of the water circulated in the condenser. Water for ammonia-condensing purposes can be obtained from deep or

[1] For articles on Performance of Ammonia Condensers see *A. S. R. E. Journal*, November 1914, and July 1918.

surface wells, flowing streams or city distribution systems; or by recirculating water that is being cooled in forced-draft, natural-draft or atmospheric cooling towers or spray cooling systems. Which method is to be preferred depends upon the temperature of the water, the dependability of the supply and the relative pumping level. The cost of pumping water from wells is ordinarily so great that a recooling system is preferred.

The proper construction of a cooling tower is far more important in a refrigerating plant than in a steam plant. In the latter we can get 25 in. of vacuum with water at 105 deg. fahr.; but in the refrigerating plant, with the same temperature, the ammonia condenser pressure would be about 280 lb.

The limit of atmospheric cooling depends upon the wet-bulb temperature. The rate of cooling depends upon the vapor-pressure difference between the dewpoint and the temperature of the cooling water as modified by the wet-bulb depression. Roughly speaking, each degree of water temperature is equivalent to three pounds of condenser pressure.

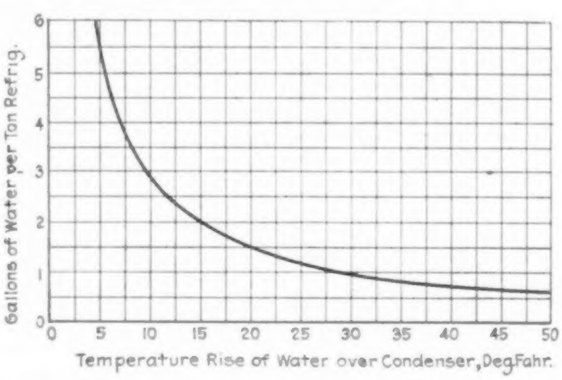


Fig. 9 Temperature Rise of Water Over Condenser with Various Amounts of Water and No Atmospheric Cooling

The use of a properly designed cooling tower is preferable to pumping water from a well, except when the well water is very cold. In summer, in even the hottest and most humid parts of the United States, the temperature of the water in the cooling tower will hardly ever be 85 deg. fahr.; it will ordinarily be below 80 deg. fahr. and in winter 50 deg. fahr. and even less. In fact, with a cooling tower it is not impossible to obtain in winter a condenser pressure of 65 lb., while with well water, the temperature of which keeps more uniform throughout the year, the pressure is higher in winter. The towers should not be built square but rectangular, twice as long as they are wide, and should be placed so that the wind strikes on the longer side.

The proper relative position of the cooling tower, as regards the condenser, is a most important feature. It must be remembered that the auxiliary power should be kept down to the minimum of $\frac{1}{2}$ hp. per ton of ice, also that if the head is reduced more water can be pumped with the same power and thus lower condenser pressures are obtained. In many plants the cooling tower and the condenser are placed on the same level with the result that two circulating pumps are operated in place of one. The relative position of the cooling tower and the condenser should always be one above the other, with the preference of the condenser being in the higher position, since unobstructed air access is more important with an atmospheric condenser than with a cooling tower. Both are more conveniently located upon a roof.

The spray system has recently been introduced in connection with ammonia condensing systems and very good resuls are being obtained. Its cooling efficiency varies from 45 to 70 per cent, depending upon humidity, wind velocity, fineness of spray and pressure at the nozzles. In the calculations which must be made for designing a spray system, however, it is advisable to figure its operating efficiency at 50 per cent. This value has been assumed in the preparation of the curves in Fig. 10, which show the value of the temperature of the water before spraying and the corresponding values after spraying, for various wet-bulb temperatures.

The advantage resulting from the use of a spray system in an ammonia condensing installation is that it reduces the power required, because a spray system does not involve the action of a fan, and a pressure at the nozzle of only six or seven pounds, that is, the equivalent of a tower 14 ft. high is sufficient. Also, the cost of construction and maintenance is less for a spray system than for a cooling tower.

Distilled- and Raw-Water Systems

The advisability of using water evaporators should be carefully considered before adopting a raw-water system in a steam plant. Where the quantity of the available water is such that raw-water ice cannot be made successfully, the installation of evaporators is highly desirable.

There are two types of evaporators, high-pressure and vacuum. Under proper conditions both give satisfactory service and neither one develops as much trouble from the formation of scale as is ordinarily assumed. The writer knows of evaporators operated successfully in a region where the water contains a large amount of salt, a large amount of carbonates, and considerable calcium and magnesium sulphate. Of course, they will have to be cleaned and blown off the same as a boiler, but their use contributes to securing a high economy and simplifies the operation of the plant.

It may be added that a plant short of distilled water is wasteful, as also is the plant that wastes distilled water. A simple steam-driven ice plant should have just enough distilled water to make the ice.

Ammonia Conservation

The chief sources of ammonia loss are blow-outs, careless purging, and leaky stuffing boxes. The first can be prevented by testing the system and keeping up with repairs continuously. Condensers, ice tanks and coils should be frequently inspected, repaired when found deficient, and tested with air of not much above atmospheric temperature. Leaks develop in the stuffing boxes through carelessness in packing them or from the bending of the rod. The only remedy is strict supervision, education of the workmen and the granting of bonuses.

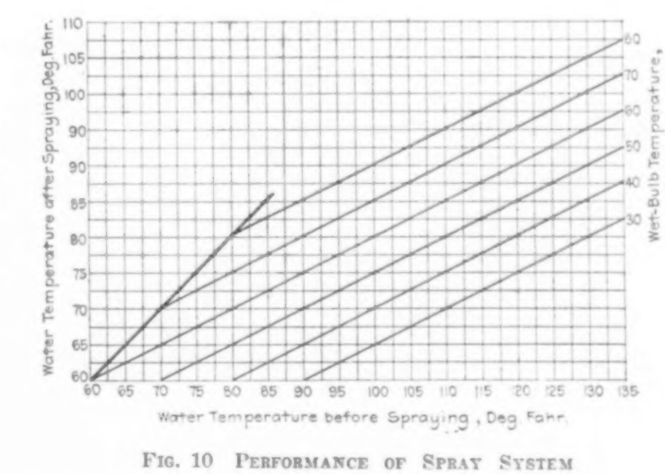


Fig. 10 Performance of Spray System

Bonuses

Bonus systems in ice plants may include bonuses paid for fuel economy, ammonia conservation, quality of ice, quantity produced and service.

The economy and ammonia-consumption bonuses are the most important, but they are defined with difficulty. In regard to economy bonuses, the best system of granting them is devised by taking the quntity of fuel used per tons of ice made in one season as an expected minimum at which no bonuses will be given, and then making a very thorough examination of the plant for the purpose of ascertaining the possibilities of increasing the output. For instance, in an ice plant making 15,000 tons of ice per year

at the rate of 1.5 tons of ice per barrel of oil, a thorough examination proved that with a slight reconstruction and improved operation, 2.3 tons of ice per barrel of oil could be expected; accordingly, Table 6 was drawn up, giving the value of the savings made and the bonus, which was taken as 20 per cent of the saving effected. The monetary value of the saving was based upon the cost of oil, in this case 80 cents per barrel.

The percentage of saving to be paid out as economy bonus will depend upon the size of the plant, the facility of making the saving, the magnitude of saving possible and the cost of fuel, but will range from 50 per cent in small plants to 10 per cent in large plants, or in plants where large savings are possible. Every plant should have an economy standard and the aim should be to do better every year.

TABLE 3 BONUS OUTLINE

Tons of Ice per Bbl. of Oil	Saving, per Cent	Cost of Fuel per Ton Ice, Dollars	Total Saving, Dollars	Bonus, Dollars	Clear Saving, Dollars	Tons of Ice per Ton of 10,000 B.t.u. Fuel
1.5	....	0.533	....	....	....	4.8
1.6	6.2	0.50	495	99	396	5.16
1.7	10.9	0.475	870	174	696	5.49
1.8	16.7	0.444	1335	267	1068	5.81
1.9	21.0	0.421	1680	336	1344	6.13
2.0	24.9	0.40	1995	399	1596	6.46
2.1	28.5	0.381	2280	456	1824	6.78
2.2	31.2	0.363	2550	570	2040	7.10
2.3	34.7	0.348	2775	555	2260	7.42
2.4	37.5	0.333	3000	600	2400	7.75
2.5	40.0	0.32	3195	639	2556	8.07

The bonus outline should be simple so the men can understand it, otherwise their interest will be greatly reduced. The bonus should be preferably paid at the end of the season, although this depends upon conditions, and any man leaving the company during the season without a good reason, or any man discharged through fault of his own, should forfeit the bonus.

The ammonia-consumption bonus should not be based only upon the amount of ammonia purchased, but rather upon the amount of ammonia in the system at the beginning and end of the season, as apparent from the liquid receiver plan gage and the amount introduced during the season.

Quantity bonuses are usually granted when the plant is operating above its rated capacity.

Quality bonuses are based on the number of good blocks of ice made, with a deduction equal to two blocks for every poor block turned out.

The service bonus consists of a certain sum which is given to the faithful employees at the end of the season. It can be based upon the earnings of the plant and be thus converted into a profit-sharing bonus; this becomes every day more advisable with the present labor situation and the high cost of operation.

DISCUSSION

Fred Ophuls spoke regarding two-stage ammonia compression. He stated that during the last few years two-stage compression had been used in refrigerating plants where it was desired to cool brine down to 10 or 20 deg. below zero (fahr.). With the higher brine temperatures, 10 to 20 deg. above zero, as used in ice-making plants, the advantage of compound compressors was not so great, and it was still a question whether in this case the increased friction of the two-stage machine did not wipe out the saving derived from compounding. There was, of course, an opportunity in ice-making to cool down the water at a high and favorable intermediate ammonia evaporating pressure, such as 40 lb. gage, but this would not exceed 20 per cent of the total work and should be done in more efficient water coolers than those used heretofore.

Regarding Mr. Azbe's statement that theoretically wet compression was more economical than dry compression, Mr. Ophuls believed the opposite to be true, as would be apparent from a careful analysis of the entropy diagram, as well as from accurately made tests. He said that in wet compression it was necessary to feed extra liquid to the compressor to take up the heat of compression, which meant an increase in volume to be handled by the piston, and therefore an increase in horsepower. He held that dry compression, in which the suction gas reaches the compressor inlet as near its saturation temperature as possible, was the most economical method known today.

Edward N. Trump spoke on the increased steam economy obtained with the uniflow type of engine over the former types in which the initial steam condensation was considerable owing to the fact that the steam on entering came in contact with a relatively cool surface. In the uniflow engine the steam traveled only in one direction, the wall and head temperature was much higher, and therefore the cylinder condensation was almost eliminated, so that a 150-hp. engine non-condensing would use only 18 lb. of steam per i.hp-hr., and condensing 1 lb. of steam, if the steam was supplied at 125 lb. pressure. The consumption curve was also very much flatter than with a Corliss engine, and the surface within the cylinder was kept very small. At light load the uniflow engine was therefore nearly as economical per horsepower as at full load. Again, it made very little difference in the total heat consumption whether the steam was highly superheated or dry saturated.

Halbert P. Hill [1] spoke in favor of the electrically operated ice plant, driven by a constant-speed synchronous motor direct-connected to the ammonia compressor. He said such motors were now obtainable for speeds as low as 50 r.p.m. without excessive cost, and that their efficiency was higher than with any other type.

George A. Horne also was in favor of electric drive, because it was mutually advantageous to both the user and the central station. The central stations had to maintain large equipments to take care of peak loads during the winter. Ice and refrigerating plants required most of their power in summer. For a number of years the central stations in large cities had offered to such plants "off-peak" contracts at attractive rates. This off-peak period might extend over two to four months in winter, during which time the customer agreed to use from 4 to 8 p.m. not to exceed 20 per cent of the preceding maximum demand. Any current used in excess of this must be paid for at a high rate, but with judicious management this penalty did not arise. In fact, it was found in two 500-ton plants that the shutting down of the main compressors for four hours was hardly noticeable in well-insulated cold-storage rooms filled with chilled goods, and even in a pipe-line system there was so much reserve capacity stored up that the heat influx during such idle time could be easily removed when the machines were started at 8 p.m. In other words, an interruption of 4 hours out of 24 proved to be entirely practical, so long as the auxiliaries were kept going, and thus large ice and refrigerating plants were in position to secure a rate as low as 0.9 cent per kw-hr.

An interesting utilization of the energy available in the steam jets emitted from the soil in volcanic regions is found at Larderello, Italy, where a central plant of 16,000 hp. is operated continuously and distributes current to Florence, Livorno and Grosseto.

The Larderello region is extensively covered with volcanic formations, the most wonderful being the so-called "soffioni," which are certain volcanic vents emitting powerful jets of very hot steam. By boring holes, powerful jets at a pressure of two to three atmospheres have been obtained. The first utilization of this steam was made in 1905 when the steam ejected at the Nenella fissure was applied to a 40-hp. engine. Later in 1912 satisfactory results were obtained with a 300-hp. turbo-alternator. The subsequent increase in the price of coal, especially during the years of the war, has stimulated the exploitation of the thermic energy of these soffioni on a much larger scale. As other substances are emitted with the steam, among them sulphuric acid, the steam from the soffioni is used only for heating. Three turbo-alternators of 3000 kw. each are supplied with low-pressure steam from boilers heated by the natural steam which is piped and carried to them.

[1] Consulting Engineer, 112 W. 42d St., New York, N. Y.

ECONOMICAL SECTION OF WATER CONDUIT FOR POWER DEVELOPMENT

By CARY T. HUTCHINSON,[1] NEW YORK, N. Y.

THE literature of water-power engineering accessible to the writer does not include a discussion of the method of determining the economical section of a water conduit for supplying water to a power plant.

In what follows a formula for the best slope and size of conduit is deduced, which takes into account in a practical manner the construction costs, the value of the power recovered, and the rate of returns expected on expenditures made, as well as the other physical conditions of the problem. The resulting relation between the best area and the quantity of water is shown in Fig. 2, for chosen values of factors entering the problem, and it is pointed out how, by a simple modification of the graphs of this figure, the relation for other costs and unit prices can be easily determined. One interesting result is that for a flume, or for any conduit, for which the increment cost for increasing the capacity by a relatively small amount is proportional to the surface, the best speed of flow of the water is constant, independent of the size of the conduit.

The economical section is evidently that resulting in the greatest net earnings of the power plant under the conditions controlling the market where the power is delivered. Inasmuch, however, as this section must be determined in advance of complete knowledge of market conditions, it is clear that only an approximation can be made, and that a ready method to determine the variation in net earnings for a large range of sections and shapes of water conduit may be useful.

Assuming that a certain shape and slope of water conduit is fixed upon provisionally, the question is whether some change either in the slope or in the shape or size of the section will result in an increase in net earnings. Any increase in the dimensions of the conduit will obviously entail an increase in construction cost, and hence an increase in annual charges. This increase in annual charges is limited, practically speaking, to interest, amortization and profit, inasmuch as only small changes in a quantity which itself is a small part of the total are under consideration. For instance, under ordinary conditions the loss in the water conduit may vary from, say, 5 per cent to 10 per cent of the total power; it is a variation of possibly 25 per cent one way or the other in this 5 per cent or 10 per cent that is involved.

It is therefore evident that no increase in operating charges, or maintenance, or repairs need be considered, and that the changes in design of the conduit should carry charges only for interest, amortization, and profit. An allowance for profit on the additional expenditure must be included, since every dollar invested should earn its share of profit as well as its fixed charges.

The increase in power resulting from an increase in the size of the conduit brings in a certain addition to gross earnings. Against this, in theory, should be charged the costs of operation and maintenance on the additional equipment and machinery required to deliver this power to the market; but for the same reasons stated in considering the water conduit, all these charges against the additional gross earnings may be ignored in this analysis, as they are negligible in amount, due to the fact that the increase in the power output is small. There would, in fact, be no increase in operating charges, and under practical conditions there would be no increase in equipment, and therefore no increase in fixed charges on equipment.

The matter then reduces to the comparison of the additional gross earnings from the power recovered by an increase in the size of the conduit on the one hand, and the additional interest, amortization, and profit on the cost of the enlargement of the conduit on the other.

The determination of additional power is simple, involving merely the overall efficiency from the water to point of delivery. A consideration of the value of this increased power is a matter of judgment on the part of the engineers and executives of the enterprise, giving attention to the market conditions under which the power is sold, and particularly to the load factor.

The determination of the additional cost of the conduit, however, is more difficult, inasmuch as this cost depends in theory not only on the area of the cross-section of the conduit, but also upon its shape; that is, upon the hydraulic radius or the wetted perimeter. The relation between the area and the wetted perimeter differs, for example, for a rectangular, a circular or a hexagonal conduit, and cannot be expressed in a simple equation to cover all shapes of conduit. The practical way to handle the problem is to fix upon one shape of conduit, determine the economical area and slope for this shape, and then follow out a similar procedure for such other shapes as may be practicable in the case under consideration. This determination being made for the several possible shapes, the best result is then selected.

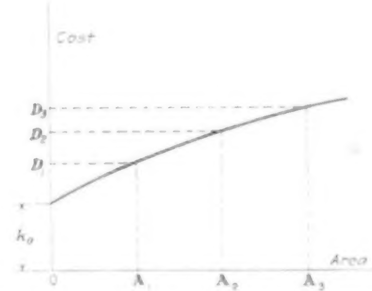


Fig. 1 Relation between Sectional Area of Conduit and Cost

The procedure indicated in the foregoing general discussion can be expressed symbolically as follows:

Let Q = flow in sec-ft., taken as constant
L = length of conduit, ft.
A = area of conduit, sq. ft.
s = slope of conduit, ft. per ft. of length
r = hydraulic radius of conduit, ft.
w = wetted perimeter of conduit, ft.
v = speed of flow, ft. per sec.
C = constant in the Chézy formula
e = efficiency from water to point of delivery $\times$ 0.085.

Then the power loss p in the conduit in kilowatts will be

$$p = eQsL \quad [1]$$

In this equation s is the variable, and any change of p is due to a change of s and is expressed by

$$dp = eQLds \quad [2]$$

If m is the annual value of one kilowatt under the ruling conditions, then

$$mdp = meQLds \quad [3]$$

is the added gross (and net) earnings due to the change in s.

As to the cost of increasing the capacity of the conduit, the flow is assumed to be given by the Chézy formula

$$v = \frac{Q}{A} = C(rs)^{0.5} \quad [4]$$

The best size of conduit is to be determined for a known value of the flow Q; that is, in Equation [4] Q is to be taken as constant. In this case,

$$\frac{dQ}{ds} = 0$$

and

$$\frac{dA}{ds} = -\frac{2}{5}\frac{A}{s}; \quad \frac{dw}{ds} = -\frac{1}{5}\frac{w}{s}; \quad \frac{dr}{ds} = -\frac{1}{5}\frac{r}{s} \quad [5]$$

[1] Consulting Engineer. Mem. Am. Soc. M. E.

For presentation at the Spring Meeting, Detroit, Mich., June 16 to 19, 1919, of The American Society of Mechanical Engineers. All papers are subject to revision.

With Q constant, a change in s can be offset by a change in either A or r, or in both; that is, either the size or the shape of the conduit can be varied to keep Q constant.

There is no way of expressing a general relation between A and r, but for any chosen shape, as, for example, a rectangle or semicircle, the area is proportional to the square of any linear dimension; that is,

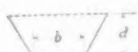
$$A = ar^2 = wr = \frac{w^2}{a} \dots\dots\dots\dots\dots\dots [6]$$

The value of a, of course, varies, but for usual forms the differences are not great, and the influence of changes in a on the economical section is slight; in fact, it can be shown that for the best section

$$A \sim a^{1/7}$$

for the conditions of Equation [7a]. Table 1 gives values of a

TABLE 1 VALUES OF SECTION CONSTANT a FOR VARIOUS SECTIONS

Shape of Section	Hydraulic Radius	Cross-Section	Section Constant	
			a	$\sqrt{a}$
Semicircle, radius $= r$	$r/2$	$\pi r^2/2$	2π	2.51
Square, side $= d$	$d/3$	d^2	9	3.00
Half-square, depth $= d$	$d/2$	$2d^2$	8	2.83
Hexagon, half-full, depth $= d$ 	$d/2$	$\sqrt{3}d^2$	$4\sqrt{3}$	2.55
Prism: 				
Tan $\alpha = 1/1.5$, $b = 4d$	$0.72d$	$5.5d^2$	10.6	3.26
Tan $\alpha = 1/2$, $b = 10d$	$0.83d$	$12d^2$	16.0	4.00

for the usual shapes. For preliminary calculations $a = 9$ may be used.

The cost of a water conduit can be expressed as a constant, representing the cost of a large part of the preliminary work and plant, plus an amount depending on the size and surface area. In general, the cost per foot may be expressed by

$$D = k_0 + kA^n \dots\dots\dots\dots\dots\dots [7]$$

where D = cost per foot, dollars
k_0 = constant part of cost per foot
k = a constant
n = an exponent whose value lies between 1 and 0.5.

In any specific case, when all the conditions are known, estimates of the total cost per foot of the conduit should be made for three or more different cross-sections; plotting these values will enable both k and n to be determined.

For example, let Fig. 1 represent the cost per foot for a certain conduit; then k_0 is given at once by the curve, and from

$$\frac{D_2 - k_0}{D_1 - k_0} = \left(\frac{A_2}{A_1}\right)^n$$

n is determined. Each pair of points should be used and the value of n found. The values of n and k_0 being known, k may be obtained from

$$k = \frac{D_1 - k_0}{A^n}$$

Other methods could be used. The gist of the matter is that the accurate way is to make detailed estimates for several cross-sections and determine the constants from an analysis of these estimates.

Two extreme cases simplify the formula: First, when the increment cost is proportional to the area, as in a heavy rock cut, then

$$D = k_0 + kA \dots\dots\dots\dots\dots\dots [7a]$$

and, second, where the increment cost is proportional to the surface, or the wetted perimeter, as for a flume, then

$$D = k_0 + kA^{0.5} \dots\dots\dots\dots\dots\dots [7b]$$

These are considered later.

If i represents the total rate of returns expected on all expenditures on the property, including interest, amortization and profit, then

$$I = iL(k_0 + kA^n) \dots\dots\dots\dots\dots\dots [8]$$

gives the total returns from this investment, and a change ds in s calls for a change in returns of

$$dI = niLkA^{n-1}\frac{dA}{ds}\,ds \dots\dots\dots\dots\dots [9]$$

or, from Equation [5],

$$dI = -\frac{2niLkA^n}{5s}\,ds \dots\dots\dots\dots\dots [10]$$

This saving, due to an increase in s, must be at least equal in value to the power lost, and indeed should exceed it by some margin; this margin can be included in the overall rate of return i, and therefore

$$dI = mdp \dots\dots\dots\dots\dots\dots [11]$$

Substituting in [11] from [10] and [3], there results

$$5meQs = 2kniA^n$$

Substituting further from [6] and [4], namely,

$$s = \frac{v^2}{C^2r} = \frac{v^2}{C^2(A/a)^{0.5}}, \text{ and } Q = Av,$$

gives finally

$$A^{n-0.5} = \frac{2.5mea^{0.5}}{nikC^2}\,v^3 \dots\dots\dots\dots\dots [12]$$

This may also be written

$$A^{(n+2.5)} = \frac{2.5mea^{0.5}}{nikC^2}\,Q^3 \dots\dots\dots\dots\dots [13]$$

If

$$N = \frac{2.5mea^{0.5}}{nikC^2} \dots\dots\dots\dots\dots\dots [14]$$

then

$$A^{(n+2.5)} = NQ^3 \dots\dots\dots\dots\dots\dots [15]$$

The best way to handle this equation for engineers is by logarithmic plotting. From [15]

$$\log A = \frac{\log N}{(n + 2.5)} + \frac{3}{(n + 2.5)}\log Q \dots\dots\dots [16]$$

When n is known, this can be readily plotted for any range of Q desired. As an illustration, assume:

$$m = \$10,\ e = 0.67 \times 0.085 = 0.057$$
$$i = 0.15, \quad C = 120$$

then

$$N = \frac{10^{-3} \times 2}{nk}$$

If, further, $n = 0.75$ and $k = \$0.10$,

$$N = 10^{-2} \times 2.67$$

and

$$\log A = \frac{\log 10^{-2} \times 2.67}{3.25} + 0.925 \log Q$$
$$= -0.485 + 0.925 \log Q \dots\dots\dots\dots\dots [18]$$

Fig. 2 is the logarithmic graph of Equation [18] for values of Q from 100 to 10,000, in four parts; for the line BC the ordinates are to be multiplied by 10 and the abscissæ by 100; for CD, by 100 and 100; for DE, by 100 and 1000; for EF by 1000 and 1000—all as indicated by the figure. From this figure, Table 2 is readily computed.

TABLE 2 VALUES COMPUTED FROM FIG. 2

Q	A	V	r	s (Ft. per 1000)
100	23	4.35	1.60	0.830
500	100	5.00	3.34	0.520
1,000	191	5.22	10.50	0.180
2,500	450	5.56	16.70	0.128
10,000	1,650	6.08	33.30	0.077

Two special cases are of particular interest: First, when $n = 0.5$ and the increment cost is proportional to the surface; this would approximate the case of a flume or a concrete-lined canal in earth. Here

$$A^3 = NQ^3$$

and, since $v = Q/A$,

$$v^3 = \frac{1}{N} \qquad [19]$$

or there is one best speed of flow independent of the size of conduit. This is a somewhat surprising result.

The second case is when the increment cost is proportional to the amount of excavation, as for a costly rock cut; here $n = 1.0$, and

$$A^{3.5} = NQ^3 \qquad [20]$$

This can be solved either by plotting, as in Fig. 2, or as follows:

$$A^{0.5} = Nv^3 \qquad [21]$$

and

$$Q = Av$$

Calculate $A^{0.5}$ and A from [21], assuming values for v; then find Q, which can be plotted to A.

Variations in A resulting from other values of the unit costs than those used in plotting Fig. 2 can be easily taken into account without replotting these curves. Put

$$N' = fN$$

then

$$\log N' = \log f + \log N$$

and a length equal to $\log f/(n + 2.5)$ added to the ordinate of the curve at any point will give the value of Y for $N' = fN$. If f is less than unity the length is to be subtracted. For example, for the point P of Fig. 2, $Q = 2500$, $A = 450$, $v = 5.56$. If $f = 1.5$, then P_1 is the point where $PP_1 = \frac{\log 1.5}{n + 2.5} = \frac{\log 1.5}{3.25}$. If $f = 1/1.5$, P_2 is the point. These values are given in Table 3.

TABLE 3

N	Q	A	v
$10^{2} \times 4.00$	2500	510	4.90
$10^{2} \times 2.67$	2500	450	5.56
$10^{2} \times 1.78$	2500	395	6.32

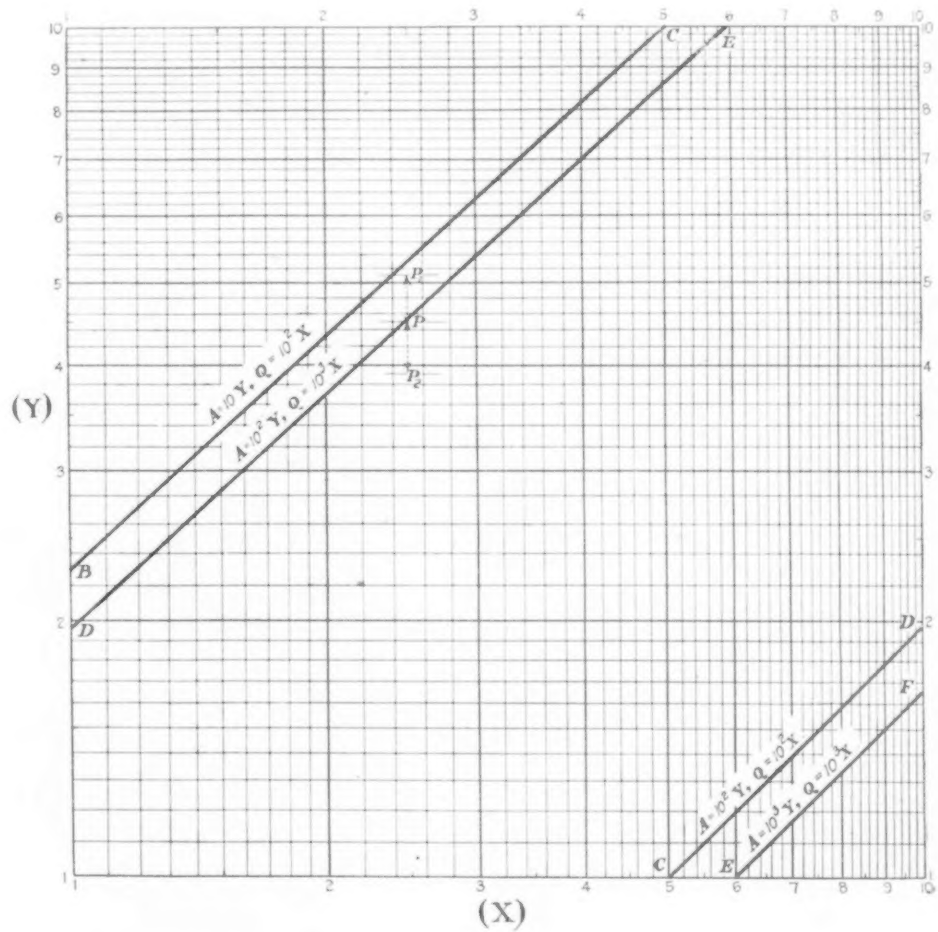


FIG. 2 LOGARITHMIC GRAPH OF EQUATION [18] FOR VALUES OF Q FROM 100 TO 10,000 SEC-FT.

The usefulness of this analysis is limited by the accuracy of the determination of n, and this in turn depends upon the definite knowledge of construction costs.

Natural gas, valued conservatively at $9,000,000, was wasted in a year in a group of Kansas and Missouri cities and towns, according to figures just gathered by the United States Fuel Administration. These figures show wastes varying from 27 to 73 per cent of the gas delivered to the gates of the cities and towns. The main cause of this great wastage is leakage due to poor construction of pipe lines.

To prevent further waste and to determine whether the fault lies with the wholesale or the distributing companies, arrangements have been made to have all wholesale meters in the affected district checked by the Division of Weights and Measures of the Bureau of Standards.

The figures of the Fuel Administration were obtained from the statistics of the wholesale companies as to the number of cubic feet of gas delivered to the gates of the cities and from the figures shown by the meters of the domestic consumers, the difference being the waste. (*Official Bulletin*, Jan. 6, 1918, p. 7)

Engineering Achievements of the Army

AMERICAN Engineers will always be remembered as the "Fighting Engineers," and yet their professional achievements during the Great War are also cause for just pride, for success has invariably attended their endeavors. During the war it is obvious that nothing could be learned of their work, but now that the struggle is over, publicity is quite proper, and an exhibition at which many war devices were shown for the first time was accordingly held at Washington, D. C., on February 21, 1919, under the direction of General Black, Chief of Engineers, U. S. A.

Before describing the various exhibits it may be well to state that the Engineering Department is charged with a great variety of duties. Throughout the war this Department not only organized and trained its own troops but also purchased, stored and supplied engineering material and equipment of every conceivable kind. The organization of the Department was also such that it could control production to meet its particular needs in the field, and early in the war, therefore, the Department found itself actively engaged in engineering research and development of new equipment.

Fig. 1 Portable Foot Bridge

To carry on their work the Engineers rapidly grew from 1.6 per cent of the total army at the beginning of the war to 10.8 per cent at the end, increasing 131½ times their original size, whereas the entire army increased only 19½ times. This tremendous growth naturally demanded considerable tonnage to maintain oversea troops and it is therefore not surprising to find that at the end of the war the engineers were using 27 per cent of all shipping to France.

Railroads

One of the first difficulties encountered by the A. E. F. was the transportation of troops and supplies from French seaports to front-line trenches. The solution of this problem was shown in an interesting exhibit of photographs. Both narrow- and standard-gage equipment were shipped overseas as rapidly as tonnage could be obtained, the latter being supplied in enormous quantities.

Locomotives, tenders and cars, usually 35 at a time, were loaded completely assembled into ships. In this manner over 1300 locomotives were shipped to France and a great saving in labor, time and money thus resulted. In this connection it is of interest to note that the Atchison railroad which operates 1400 miles of track in France has but 1000 standard-gage locomotives.

The number of cars sent abroad, if placed end to end, would extend 140 miles, and if the armistice had not been signed there would have been by July next 682 miles of cars alone.

That the cost of railroad equipment could be lowered in war time seems incredible, but by adopting American manufacturing methods locomotives which were costing the French $51,000 were obtained, even at a time when the price of material was rising, for $37,000.

The narrow-gage railroad proved of great value, especially near the front, because the tracks could be more easily and quickly repaired than roads, and in addition the cost of transportation was only about one-seventh that of haulage by trucks.

Bridges

An exhibit which invited special attention was a collection of photographs showing several types of portable and pontoon bridges designed especially to support heavy loads occasioned by the introduction of the tank and heavy mobile artillery.

Portable steel bridges were manufactured in sections 10 ft. long. They are designed so as to be rapidly bolted together and thus could easily be transported on trucks; and because they can carry loads as high as 30 tons, even tanks could be driven over them. They were used extensively along the fighting fronts, as the forces advanced, to replace bridges that had been destroyed by the enemy.

The construction of the ordinary pontoon bridge was also so modified that in place of the usual loads of 3½ tons per axle the bridges were able to support a load of 15 tons per axle and in addition 30 men. These bridges can easily carry the heaviest mobile artillery, and a raft is now being developed from pontoon material which it is expected will carry the famous 30-ton tank.

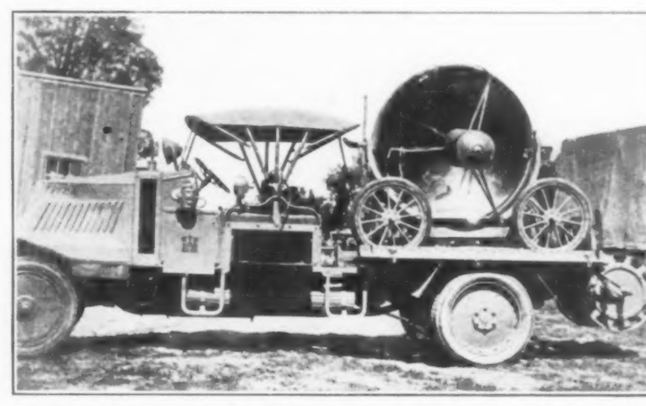


Fig. 2 60-in. Portable Searchlight on Truck ready for Transportation

Not all the design and development work was done in this country, however, for one of the most valuable bridges was a light foot type, designed and perfected by an engineer officer in France. This bridge is supported on boats made of canvas stretched on wooden frames. Duckboards form the floor. A single truck can carry 285 ft. of this bridge and it can be erected by a few men in a very short time.

In the crossing of the Meuse and the taking of the heavily fortified heights on the east of the river these bridges proved invaluable. In some cases they were put up under heavy fire, and the bridge which was thrown across the Canal de l'Est near Dun-sur-Meuse (Fig. 1) was under machine-gun and shell fire 26 hours before the infantry could cross.

Searchlights

As an example of American method of development an exhibit of searchlights showed what could be accomplished even in a short time.

At the opening of the war the Army-type searchlight had been developed only for battlefield illumination and seacoast defense. The best-known type of such lights was the 60-in. seacoast model which weighed 7500 lb. and cost approximately $10,000. By the

elimination of heavy fittings and the protecting glass doors in front and substituting Ford wheels and axles for the cumbersome old type of mounting, an equally powerful light was obtained which costs, however, but two-fifths as much, weighs but 900 lb. and can be much more rapidly manufactured. This new light is known as the portable open type, and Fig. 2 shows how easily it can be transported.

In connection with the development of these lights the subject of mirrors naturally arose, with the result that metal mirrors will perhaps soon replace all glass ones. It was found that the glass mirrors required considerable time to manufacture, and that only one firm in the United States was properly equipped to do the work. Research was at once started and metal mirrors were soon being manufactured at a cost one-third that of glass. The process is an interesting one, and is briefly as follows:

The glass portion of a mirror is first made in the usual way. This glass first receives a silver coating, and next metal is deposited on the silvered surface. When the deposit has reached the required thickness of about $\frac{3}{8}$ in. the glass is pried from the metal. Thus the glass is used only as a form, and the process can be easily repeated. Unskilled labor, it is stated, can produce very satisfactory mirrors and an adequate supply was thus assured.

These mirrors have given very satisfactory results. They run cold even when used in lights carrying from 400 to 500 amperes, and their freedom from all ordinary accidents to which glass mirrors are subject makes them very popular.

Map Production

The demand for maps of all kinds was tremendous, as military operations could not be successfully carried out unless charts were available in large quantities. An exhibit of a portable map-reproducing set which went with each division disclosed the fact that American engineers could turn out 1,300,000 maps every 24 hours. The United States Engineers' map-reprodaction plant in France was said to be larger than any similar plant used by the Allies.

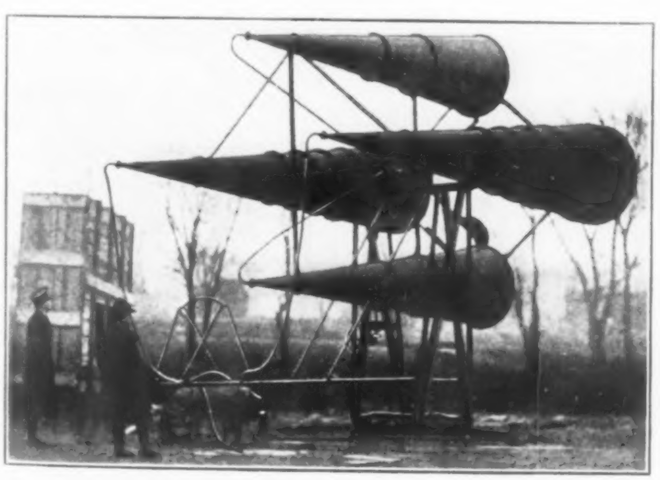


Fig. 3 Long-Horn Listening Device for Locating Enemy Aircraft

Lithographic machinery on portable truck bodies, which could be lifted from the truck and placed on the ground, thus releasing the truck for other service, were also available, and the 29th Engineers had as part of their equipment machinery of this type whose capacity was greater than that of the permanent Geological Survey map-reproduction plant in Washington.

Map production from aerial photographs was made possible by the Bagley cartograph. This machine takes three pictures at a time from an airplane, mapping a strip 3 miles long and $\frac{1}{2}$ mile wide at an elevation of 4000 ft. The pictures can be easily matched together, and an exceedingly accurate map is thus obtained.

Forestry Operations

As illustrating still another field in which the engineers were engaged, one exhibit treated of lumbering in France. In one month alone 50 million board feet of sawed lumber was produced, a pile 10 ft. high, 12 ft. wide and 6.6 miles long. Eighty thousand cords of wood were also cut, and this if piled 4 ft. high and 8 ft. wide would extend 60 miles. In addition standard-gage railway ties were produced sufficient to build a single-track road 1091 miles long.

Camouflage

Camouflage in all its various forms has been treated of time

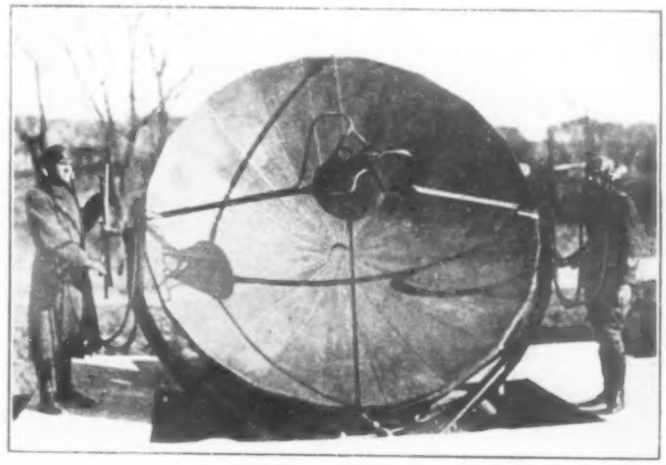


Fig. 4 American Paraboloid—A Development of the Long-Horn Set

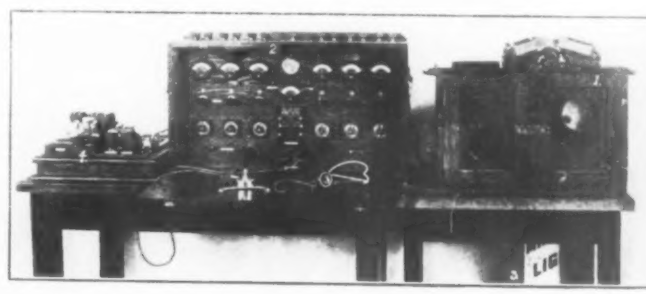


Fig. 5 Phonotelemeter—American Sound-Ranging Set for Locating Enemy Batteries

and time again, but the following facts as brought out by one of the exhibits may perhaps be of interest.

The Central Camouflage Works at Dijon produced daily 50,000 sq. yd. of camouflage cover. This tremendous output soon exhausted both the European and American supply of burlap, which formed the chief material for sniper suits, camouflage loopholes, observation posts, etc. A more economical material was soon developed and produced in the United States. This consisted of a 2-in. wire mesh partly covered with a light cloth and sprayed with paint. This proved very satisfactory and could be very easily and economically manufactured.

Listening and Sound-Ranging Apparatus

The exhibit of devices for locating mining operations, for detecting the approach of hostile aircraft, and determining the positions of the enemy guns was perhaps the most complete and entertaining of all.

Geophones and microphones, both mechanical and electrical types, were successfully used in stopping mining operations. These instruments, which operate in manner similar to the stethoscope, were developed by American engineers to such a point that their value was increased about 30 per cent.

Listening devices for determining the direction of approach of hostile aircraft at night had long been in use. The original long-horn listening device as built by the French (Fig. 3) was, however, a cumbersome affair and could be moved only with the greatest of difficulty. Again American methods came to the rescue, and an equally effective but portable apparatus of the parabolic type (Fig. 4), with the famous Ford wheel and axle again in evidence, with plaster-board detecting surfaces, was soon available; and, as might have been expected, at nearly one-third the original cost.

Perhaps the most delicate technical instrument developed and in use during the entire war was the phonotelemeter, shown in Fig. 5. This instrument not only locates an enemy battery, but it gives the caliber of the gun as well. These remarkable results are obtained merely from the report of the gun. The operation of the instrument is chiefly electrical, and, surprising as it may seem, it is not affected by rifle fire. A single set covers a 5-mile front, and it is reported that one section located 117 guns or batteries in 24 hours.

The English apparatus, known as the Bull-Tucker, makes a photographic record of the disturbance caused by the report of each gun. The French and American developments used a smoked tape for recording the firing, and to make the record permanent the tape is afterward sprayed with wax. This method gives the information desired in a much shorter time.

According to all reports, the Germans never possessed any such remarkable instrument, nor anything that could even be called similar in its nature.

It was by means of this instrument that one of the long-range guns which fired upon Paris was finally located and destroyed. After the armistice was signed, a survey taken by an American officer showed that in every case the location of enemy guns was within 20 to 30 ft. of that as determined by the phonotelemeter.

A flash-ranging device, also electrically operated, was extensively used upon the western front. This device is used in conjunction with observation telescopes for locating enemy batteries from the flash of their guns, and it proved very effective. It can be used either for day or night work.

The exhibits just described comprise the more important developments of the Engineering Department in the United States, and touch only here and there upon the activities of the Engineer Corps in France. "Over there," of course, the real construction work was done, for all fortifications, roads, railways, docks and warehouses, camps and hospitals, water-supply systems and sewers were the work of the engineers.

READJUSTMENT OF INDUSTRIES TO PEACE CONDITIONS

By JAMES D. MAGEE,[1] CINCINNATI, OHIO

BEFORE discussing the problem of readjusting to peace conditions, it will be well to recall something of the organization of modern business. In pioneer days each family was nearly self-sufficing. It produced the things which it needed to eat and wear. Now, as the result of ever greater and more complex division of labor, the ordinary man spends all of his time performing some small part in the manufacture or marketing of a product. The result of the change is greater interdependence. The individual is dependent upon the proper functioning of the whole system for the disposal of the product in which he is interested and for the possibility of purchasing the things he desires. Again, it is well to recall the method by which the decision is reached as to what will be produced. With few exceptions things are produced because some one thinks it will be profitable to produce them. That is, price levels and profit margins are relied upon to direct production.

The problem confronting us as we entered the war may be stated in general terms as follows: We had certain limited amounts of labor, land, materials and equipment. Some of the men were to be taken as soldiers and sailors. The remaining labor and resources had to be utilized to provide the food and clothing and munitions for the army and navy or equipment to make them, as well as to support the home population. The problem was how to shift labor and equipment from non-essential to essential industries. The readjustment was brought about by the appeal to the desire for profits and by the use of priorities in the supply of materials and in transportation. Any quick readjustment is difficult, but this one was made easier because it took place in connection with an almost unlimited demand for the products of industry which showed itself in rising prices.

Now we have another problem of readjustment. The men are returning from France and the training camps. The Government demand, backed by unlimited purchasing power, has fallen off. The labor, land, materials and equipment must be used to make things wanted by people in general. This readjustment will be more difficult as it will probably take place with prices falling.

The nearest analogy to this condition in our history is the situation of the North after the Civil War. Then an army of a million men was demobilized without any trouble. Agriculture, manufactures, mining and foreign trade all increased. It will be instructive to examine the two cases to find wherein they are alike and wherein different.

The cases are alike in that the fighting in the Civil War was done mostly in the South and in the present war in Europe.

Our general economic organization has become more complex since the Civil War. Specialization and division of labor have been carried to a greater degree. At present many men's chances of employment depend upon whether people will want enough of a certain article to justify some one ordering a machine which will be used in making it. This complexity makes our present problem more difficult.

After the Civil War many of the men went west to take up the free fertile land which the Homestead Act of 1862 had made available. They could take up this land and at least make a living without needing to bother about markets. At present the free fertile land is exhausted, so this easy solution is not possible. Secretary Houston proposes to reclaim and irrigate land to give to the returning soldiers, using the labor of the soldiers, in this way helping to give employment in the transition period.

After the Civil War many of the returning soldiers helped build railroads in the West. While at present there is not much need for new railroads, there is certainly a great deal of deferred maintenance which should provide employment.

The Civil War brought an increased use of agricultural machinery in the North. By this means the total product was increased, although the labor force was smaller. The increased production lasted after the war and formed the basis for an export trade in agricultural products. Much machinery was introduced in manufactures also. The present war has both intensified the use of machinery and increased our equipment of various types of plants. It remains to be seen whether our initiative will be great enough to use the plants for peace goods and develop large production as was done after the Civil War.

It is hard to form a judgment in the matter of possibilities for foreign trade. Europe had not been involved in the Civil War, and when it was over was ready to take large quantities of our exports. At present there is no question about the need for food and equipment in Europe, but the credit arrangements present a serious problem.

We are decidedly better off with regard to our monetary system than the country was after the Civil War. The inconvertible greenbacks had driven gold out of circulation and prices moved wildly. Our present monetary system is sound. Prices rose compared with pre-war prices in both cases. Prices in 1866 were higher than in 1865 and after that declined gradually.

The whole problem of readjustment is one of producing things which satisfy the new demands. People desire many things they have been forced to do without for the period of the war, and many of them, for example, the railroad employees, have greater purchasing power than they have ever had before.

[1] Associate Professor of Economics, University of Cincinnati.

Synopsis of remarks before the Engineers' Club of Cincinnati, November 21, 1918.

Heavy Field Piece With Mobile Mount

By ENSIGN C. L. McCREA,[1] U. S. N. R. F.

DURING the war the Navy Bureau of Ordnance originated a number of remarkable projects, and their success has been due in no small measure to the sound engineering principles applied in design and construction. Practically all of this development work was done by officers of the reserve force, graduate engineers and men of high standing in their profession. Among their many remarkable achievements was the design and construction of an entirely new type of mount for a high-power 7-in. gun. The evolution of this mount dates back to our entry in the war.

The Navy was naturally charged with the organization of a convoy system and ships of the *Connecticut* class were at once assigned to this duty. This of course meant that the convoy was to engage submarines that might appear, and it is generally conceded that submarine-offensive guns must be light, quick, and hard-hitting.

It was therefore decided that an improvement in the armament of the battleships could be made by substituting 5-in. 51-caliber guns for the 7-in. 45-caliber battery. This change was approved early in 1918 and the substitution of guns was begun at once. This left a number of 7-in. guns available for other service, and the urgent need of our forces in France for artillery turned attention to the possibility of placing these excellent guns in action on the western front.

The Army soon received a number of these 7-in. guns, which they mounted on railway cars especially built with a drop-frame bed so that the entire gun and its mount, exactly as it was used on board ship, could be placed on it.

This method of mounting the gun was unfortunately limited in its use by the fact that the elevation set by the naval mount, 15 deg., was still maintained, which limited the range to 14,000 yd., or about 8 miles. Furthermore the heavy trunnion pressures arising from the short length of recoil, while entirely satisfactory on board ship, were troublesome on a railway mounting, and strong outriggers and considerable bracing of the car and bed were required when the gun fired at targets at an angle to the line of the track on which it was located.

The Navy, in considering the uses to which these guns might be put, naturally first thought of placing them upon railway mounts. They planned however to give the gun an elevation of 30 deg., to lengthen the recoil and to modify the mount so that little or no bracing would be required when the gun was fired. While designs for this type of railway mount were being worked out, word was received that better use could be made of the guns if a suitable field mounting were developed, and on March 15, 1918, work was therefore started along such lines of design.

Fig. 1 High-Power 7-in. Gun with Caterpillar Mounting

The problem was to obtain a mobile field mounting for a gun weighing nearly 15 tons. The mount was also to permit transportation of the gun and mount as a unit, so that no preliminary preparation of the gun was necessary before firing. The 7-in. gun was the heaviest and hardest-hitting gun for which a mobile field mount of this kind had ever been contemplated, and in addition, the time allotted for design and construction was exceedingly short, as the mounts were desired in France before the close of the year 1918.

A study of existing designs was immediately commenced and it required but little study to show that a wheeled mount for the 7-in. gun was not practicable. The weight of the completed mount would be in the neighborhood of 70,000 lb. Assuming a 6-ft. wheel and an arc of contact of 25 deg. with the ground, the total bearing surface to carry the load would be about 6 sq. ft. This gave a ground pressure of about 6 tons per sq. ft., or 88 lb. per sq. in., a pressure of course out of the question, as the gun would undoubtedly become hopelessly mired

[1] Bureau of Ordnance, Washington, D. C.

when it encountered even slightly soft ground. Furthermore, large-wheeled mounts are difficult to place into position and correctly aim, and their tendency to roll back on firing makes rapid and continuous fire a difficult task.

In the face of these difficulties, a search was made for some better method of mounting the gun, and the principles of the so-called "caterpillar" belt for transporting the mount were suggested. Instead of wheels it was proposed to use a steel frame with rollers carrying a link belt presenting a large surface to the ground. Such a mount had never been used for a gun in which the reactions and weights were so great, and yet there appeared to be no serious objection to the idea. Sufficient strength could be given to the construction to carry the loads imposed, and preliminary calculations showed that a ground-contact area of 28 sq. ft. would be obtained, giving a pressure of 18 lb. per sq. in.—less than that of a horse. Designs for a mount of this construction were accordingly commenced.

It was hoped that a number of parts, such as the gun slide, recoil mechanism, etc., from the marine type of mount might be incorporated into the new land mount, but on consideration it appeared more desirable to lengthen the recoil of the gun as much as possible, reducing the trunnion pressure on firing, and in turn the weight of the mount, rather than to build a heavy mount capable of standing the heavy recoil forces. Furthermore, the counter-recoil mechanism was designed to return the gun to battery only at elevations up to 15 deg., and as an elevation of 40 deg. was contemplated in the new mount, a new design of counter-recoil mechanism was necessary. The designers therefore soon found that they must work from the ground up. Every part of the mount had to be newly designed, only the gun and yoke being used of the material taken from the battleships.

The Naval Gun Factory had preliminary designs for the new mount out within a fortnight. They called for a mount with caterpillar-belt wheels, a structural-steel carriage, made of shapes easily obtained, a gun slide equipped with hydraulic recoil and pneumatic counter-recoil systems and having an allowable travel of 32 in. in recoil, which reduced the trunnion pressures to approximately 120,000 lb.

The designs submitted were at least a year ahead of current development, yet they were so carefully worked out that they met with instant approval, and authority was given to proceed with the details. On May 25, 1918, the detailed designs were pronounced complete, and, shown on 164 separate drawings, were ready for submission to the bidders.

Design of the Mount

Caterpillar Wheels. The caterpillar wheels, on which the gun and carriage rest, are of the naval type. The wheel itself consists of an endless belt of cast-steel links connected by hardened pins. Each link carries a corrugated forged-steel plate which makes contact with the ground, the plates overlapping so that a continuous surface is presented. Detachable grousers are provided to prevent slipping when descending hills in rainy weather.

Within the belt are arranged the sprocket and roller wheels, all carried on a steel beam of special design. The sprocket wheels carry but little of the load, except when the gun is descending a hill or the brake is applied. Eleven truck and idler wheels, 7 below and 4 above, support the belt and carry the load.

A brake is provided to permit control of the mount when descending hills, and also to lock the caterpillar in position when the gun is set up for firing. This brake consists of a toggle joint operating on the rim of one of the sprocket wheels, and although exceedingly simple, has proved very satisfactory.

Gun Carriage. In the design of the gun carriage, standard structural shapes were utilized as far as possible, as it was realized that under existing war conditions special work could be obtained only with difficulty. The carriage consists of two side girders, cross-braced at each end to form a unit with a central well into which the gun recoils. A traversing gear is built into the rear end of the carriage to permit of accurate aim. This gear consists of a cast-steel plate which rests on the ground underneath the structural work of the trail, being held thereto by clips. A worm shaft operated by ratchet wrenches shifts the trail with reference to the plate and enables the gun to be accurately trained.

The trunnion seats are placed at the upper end of the carriage. Navy guns do not carry the trunnions attached directly to the gun, but are turned to a smooth surface on the outside. A cylindrical casting, known as the gun slide, to which the trunnions are attached, carries the gun. The gun slide also carries the recoil and counter-recoil mechanisms. These are contained in cylinders, and operate through pistons attached to the gun yoke. The slide is fitted with bronze liners, on which the gun bears when it slides in and out on firing.

In the 7-in. caterpillar mount the trunnions of the gun are mounted sufficiently high so that at maximum angles of elevation only a shallow trench about a foot in depth is required to allow clear space for the recoil of the gun.

Recoil and Counter-Recoil Systems. Recoil of the gun is taken up by means of a simple hydraulic brake, in which the energy is absorbed by forcing a mixture of glycerine and water through orifices of gradually decreasing diameter.

An elevation of but 15 deg., it will be remembered, was permitted by the mount in which the gun was carried on board ship. When so mounted springs were used to return the gun to the battery, or firing, position, and these functioned satisfactorily. The high elevation of 40 deg. permitted in the new type of mount, however, made spring return impossible.

Pneumatic system for counter-recoil return are in quite extensive use abroad, and these were investigated in the search for a proper mechanism. After a considerable study it was decided that the French type of mechanism, as used on 155-mm. guns, would do the work. In this type when the gun fires, a piston attached to the gun yoke moves backward in an airtight cylinder containing air at a pressure of several hundred pounds per square inch, and this air pressure brings the gun back when the gun has reached the end of its recoil.

The objections to the adoption of the French system were the exceedingly close limits to which it was required to machine the parts, and complications in the mechanism itself. Moreover, all the parts are arranged in one cylinder with a view to extreme compactness. Accordingly, the entire mechanism was redesigned to adapt it to American methods of manufacture.

In Fig. 1 the counter-recoil mechanism can be seen located on top of the gun slide (the recoil cylinder is located below). As redesigned, it is a combination of three cylinders, connected at the lower end by a cast bronze head. The piston attached to the yoke operates in the central cylinder. A simplified system of liquid packing is retained. The entire system is made up of shapes and materials easily secured, requires the minimum of machining, and on the whole is well adapted to American manufacturing methods.

Tests

On September 26, just one hundred days from the date the contract was placed, the first two gun mounts, complete and ready to fire, were shipped to the Naval Proving Ground, at Indian Head, Md. On their arrival the guns were first given a road test. Up hill and down they were hauled, over rough ground, and along hillsides at an angle. They proved themselves able to negotiate any ground over which the tractors themselves were able to operate. Obstructions were mowed down, and yet the weight of the gun and mount was so evenly distributed that no damage was done even to roads when it was necessary to traverse them.

The guns were proof-fired, and every expectation of the designers was fulfilled. The range of the gun, at its maximum elevation of 40 deg., was 24,000 yd., as predicted. No bracing of the mount was necessary other than a few timbers laid in the ground under the trail to distribute the load. The caterpillar tread, locked in position by the brakes, was as steady as a concrete foundation, and the gun remained steady on the point of aim even during continued firing. The counter-recoil mechanism and all the other parts of the mount functioned perfectly.

Diesel Engines and the Merchant Marine

Review of Developments on the Pacific Coast

In an endeavor to answer the question: Why is the internal combustion engine not used more extensively for marine propulsion? the San Francisco Section devoted its meeting of December 19, 1918, to a discussion of the Diesel engine as applied to the merchant marine. The papers presented were chiefly a record of past performances of motorships on the Pacific Coast, but it was also pointed out that the internal-combustion engines are rapidly assuming greater importance, and may ultimately replace the steam engine.

Bruce Lloyd, marine engineer for the Concrete Ship Section of the Emergency Fleet Corporation, discussed the attitude of the ship owner and gave valuable data of performances. George A. Dow, president of the Dow Pump & Diesel Engine Co., presented a paper on the Diesel oil engines of the motorship *Libby Maine*. Both of these papers are abstracted below.

J. H. Hanson, president of the Scandia Pacific Oil Engine Company, also read a short paper illustrated by about forty slides, covering the history and development of Diesel engines and showing some of the more recent installations on ocean-going vessels.

Perhaps the most interesting fact brought out by Mr. Hanson's remarks was the statement that there are nearly 800 motorships varying from 1000 to 12,000 tons capacity now in operation. Some of these ships are making from 40- to 50-day continuous runs covering more than 10,000 miles and carrying cargo of 11,000 tons. These ships consume during such voyages 400 tons of fuel oil instead of the usual 1500 tons of coal of the ordinary steamer, with a resulting saving of approximately 1000 tons in fuel and in addition making available another thousand tons of cargo space.

Diesel Engines on the Pacific Coast

Bruce Lloyd

The development of the steam engine, extending over a period of about one hundred years, has now reached such a stage that it is probably one of the most perfect machines that has ever been produced. The steam engine is wonderfully smooth-running and possesses great flexibility of power. And yet the ship owner is constantly being urged to discard his steam engine and install internal-combustion engines, and for the simple reason that the steam engine is not complete in itself. Its future is doomed by its necessary adjunct, the steam generator, which has never been improved so as to remove its attendant danger and other well-known disadvantages.

The space occupied by the boiler in a steamship, together with the large amount of room necessary for fuel, is the most perplexing problem that presents itself in the construction of a serviceable and economical cargo carrier. Attempts have been made to overcome this objectionable feature by placing the boilers on the upper deck of the ship, which is not so valuable for cargo space, but the fact remains that the boilers are still on board, adding at least their weight and detracting just so much from the general efficiency of the vessel.

In spite of the fact that the internal-combustion engine overcomes this difficulty and gives a tremendous advantage in cargo-carrying capacity, steam-driven vessels have been clung to with a tenacity equaled only by our forefathers in their unwillingness to discard the sailing ship and adopt the steamer. So strong was their distrust of the steam engine that it is only within the last fifteen years that owners of steamships were able to overcome their fears that the steam engine might break down and dependence have to be placed on sails, as all ships up to that time were provided with considerable sail area.

There are, however, other and perhaps more weighty reasons which prevent the ship owner from adopting the internal-combustion engine. Almost every port is provided with facilities for repairing the boilers and engines of the ordinary steamship; and engineers skilled in the operation of a steam engine are always available. On the other hand, facilities for ships whose motive power is the fuel-oil engine are not even now available.

Despite these disadvantages, however, the internal-combustion engine is rapidly being adopted by ship owners, and any reliable record of performance is at once a source of interest.

During the past two and one-half years 16 vessels on the Pacific Coast have been equipped with the Bolinder crude-oil engine, manufactured by J. C. Bolinder, of Sweden. Ten of these are so-called auxiliary ships in which the sail power predominates. All of them are engaged in overseas trade, visiting ports where fuel is either not available or only at prohibitive prices. Fuel tankage had therefore to be provided, of sufficient capacity to supply the engines, when running at full speed, for a voyage outward and homeward of nearly 17,000 miles.

These ships vary in size from 1500 to 3500 deadweight tons, and the size of the engines with which they are equipped ranges from 320 to 600 hp. These engines are of the direct reversible type. They have no camshafts or intricate gearing; a small compressor driven off the forward end of the crankshaft supplies air for vaporizing the fuel on entering the cylinder; and the reversal of the engine is affected by preignition.

The first large auxiliary ship equipped was the *City of Portland*, one of the three sister ships built and owned by the McCormick Steamship Company, of San Francisco. These vessels are approximately of 3500 deadweight tonnage and are equipped with twin engines of 320 b.hp. each. The engines have often run continuously for 45 days. The average speed maintained was 6.8 knots, but when the engines were allowed to develop their full power the speed averaged 7.5 knots. The sails were of practically no use on any of these voyages, and these vessels would more properly be designated as low-powered motorships.

The daily fuel consumption averaged 23 bbl. of oil of 24 deg. B. gravity, and for a voyage covering 17,000 miles, 1997 bbl. of fuel oil were used.

The motorships that have attracted the greatest attention, however, are the full-powered vessels, as these afford the best opportunity of comparison with steamships. Four such motorships (twin-screw) have lately been added to the fleet of W. R. Grace & Co. They are excellent examples of the possibilities of moderate-sized ships equipped with fuel-oil engines. These ships, all of the same design, are the *Santa Elena, Santa Isabel, Santa Cristina* and *Santa Flavia*, and their dimensions are as follows: Length, 235 ft.; breadth, 42 ft.; depth, 29 ft.; cargo capacity, about 2000 tons on 18 ft. 6 in. draft. The propelling machinery of each ship consists of two 320-b.hp. Bolinder engines. The main fuel supply is carried in steel tanks having a total capacity of 1770 bbl., sufficient for nearly 75 days' running, and the extensive radius over which these vessels are able to travel without refueling gives them an immense advantage over the ordinary steamer. The auxiliary machinery consists of one 15-b.hp. Bolinder engine direct-connected to a 10-kw. generator and one rotary pump of 2500 gal. capacity; also one 8-b.hp. Bolinder engine connected to a 5-kw. generator and rotary compressor. These ships carry a refrigerating plant consisting of a 1-ton Brunswick motor-driven ice machine, and each has about 600 cu. ft. of refrigerating space. All of these vessels have completed voyages to New York, via Valparaiso, calling at other South American ports and the Panama Canal—a distance of over 14,000 miles, at an average speed of 180 nautical miles per day.

The engine troubles that developed have been chiefly cracked cylinder heads and broken compressor shafts. It was noted that the fracturing of the cylinder heads always occurred while maneu-

vering the engine in entering or leaving port, and never at sea. This, it was found, was caused by the overheating of the head when the engine stopped, as the circulating pump of the water-cooling system was driven from the main crankshaft. The sudden cooling and contraction which thus took place when the engine was started again has been entirely eliminated by devising means to keep a constant circulation of water through the cylinder heads even while the engine is at rest.

The breaking of the compressor shaft which occurred in the first three installations was due to a mistake in design which was quickly and easily rectified, and there has never been a recurrence of this trouble.

A steel motorship of 3500 tons carries on a direct voyage of 8,000 to 10,000 miles nearly as much revenue-producing cargo as a steel steamer of 5000 tons of the same speed, as the following table clearly shows:

	Motorship.	Steamer.
Deadweight tonnage	3500	5000
Fuel oil for 45 days at 5 tons per day, tons	225	....
Coal for 45 days at 25 tons per day, tons	....	1125
Water for boiler, tons	....	100
Net paying cargo, tons (deadweight tonnage minus fuel and water)	3275	3875

It is not intended, however, to advocate the internal-combustion engine for passenger ships, or for vessels carrying cargoes which must be transported within the shortest possible time, since in these cases the necessity for speed relegates the question of economy to a place of secondary importance.

Merchant ships and steamers, on the other hand, are operated solely for profit, and the hull that can carry the most cargo at the lowest cost is obviously the best.

In 1911 a ship propelled by a new type of engine entered our port after making a most successful voyage from Copenhagen, Denmark. This vessel, the motorship *Siam*, was owned by the East Asiatic Co., and equipped with a type of engine known in Europe as the Diesel engine. Vessels propelled by this new type of engine repeatedly visited our coast and soon were making the trip to the Pacific Coast and thence to the Orient and back in a perfectly satisfactory and efficient manner.

In 1916, when ships were greatly needed to carry our products to Europe and were being built as rapidly as possible, the great problem of obtaining machinery presented itself. Engine manufacturers were building steam engines and boilers for large steel ships and could give no time to the building of engines for smaller craft. The average ship owner was therefore glad to get whatever he could.

When the wooden sailing vessel was decided upon to meet the great emergency, the so-called semi-Diesel type of engine was adopted as an auxiliary. Subsequently, however, it was used as a full-powered propelling unit and thus a practice new to the shipping men of the Pacific Coast and untried by the manufacturers came into vogue. Since this proposition at once had associated with it the successful practice of the Europeans, the semi-Diesel gained great popularity.

A good many types of American-built Diesel engines have been installed and tried out. Marine engineers have had their opportunities to prove their skill in operating them, and the time is rapidly approaching when the ship owner will see that the American-built internal-combustion engine occupies a front-rank position as a prime mover in ship propulsion.

Performance of the "Libby Maine"

George A. Dow

A Diesel-engine installation watched with unusual interest on the Pacific Coast is that on the *Libby Maine*. This vessel is a 2000-ton wooden ship of very rugged construction, and built especially for severe arctic service. She is 240 ft. long, 43 ft. beam, 24 ft. molded depth, has a mean draft of 22 ft. 8 in., and is equipped with two 424-i.hp. Dow full-Diesel-type oil engines. These are direct reversible and are connected through Falk reduction gears and Nutall flexible couplings. Each unit is tied to an engine bedding designed to give the maximum stiffness and greatest security against deflection. Heavy timbering securely bolted to the ship's frames run in single lengths the entire length of the engine unit. The Nutall flexible coupling is placed between the main engine and reduction gear to relieve any possible strains between these units, as well as to act as a float. The reduction gear and thrust block are bolted to a single heavy cast-iron sub-base. By the use of the reduction gear the most efficient engine speed of 250 r.p.m. and the most efficient propeller speed for this size of ship, 100 r.p.m., are obtained.

The engines installed in the *Libby Maine* are of the six-cylinder open A-frame type of construction. Six cylinders were used in order to give maximum flexibility and positive starting positions, and the A-frame design was adhered to because it afforded the greatest accessibility to the bearings and pins. Marine engineers are anxious to know where their pins and bearings stand and feel more secure when they are able to "feel" parts subject to heating.

The cylinders are separate castings; cylinder heads are of standard box construction and pistons are of the long trunk type. The crankshaft is in two sections, the forward and after section being interchangeable. The lubricating system is controlled by drip oilers, the oil being measured into individual positively timed oil pumps attached to each A-frame. One plunger of this pump supplies the piston lubrication and the other the piston pin. The main bearings are lubricated by ring oilers and the crankpin by centrifugal oil rings.

The operation of the entire engine is controlled by three levers centralized at one station. A novel feature of this installation is that one man is able to control both engines from one platform. Even in the treacherous waters of the Bering Sea this control was absolutely responsive to the captain's wish.

Two levers are used to govern the action of the engine, while the reversing mechanism is manipulated by the third lever. Reversing is accomplished by the single movement of a vertical sliding cam, actuated by an oil-compensated air piston, which automatically lifts the cam rollers clear of all the cams, then slides the camshaft to the desired position and finally returns the cam rollers to the cams, thereby giving the proper timing of the valves for the new direction of rotation.

Air pressure is then applied to the pistons of the engine through the air starting valves by a single movement of the control lever until momentum is acquired, when another single movement of the same control lever automatically cuts off the air pressure and admits the fuel oil to the cylinders. The entire mechanism is thoroughly interlocked to guard against any false move on the part of the operator. Automatic locking devices block the execution of any movement not made in the proper sequence. The speed of reversal is controlled by the pressure of the air applied to the air piston of the reversing cylinder and the regulation of the velocity of oil displacement from one side of the piston to the other.

In order to obtain flexibility of operation, economic use of starting air, and added security against a shutdown of the entire unit, two control levers are provided, one lever for each set of three cylinders.

The general characteristics of the engine are: i.hp., 425; bore, 12 in. stroke, 18 in.; crankshaft diameter, $7\frac{1}{2}$ in.; speed, 250 r.p.m.; floor space, 20 ft. by 5 ft. 1 in.; height above center of crankshaft, 8 ft. 10 in.; approximate net weight, 125,000 lb.

An ideal trip from Seattle to Honolulu and return to San Francisco was experienced and a record in fuel economy made. Extracts from the official log indicate the following:

Fuel-oil consumption, bbl.	259.5
Total distance, miles	2440
Time of voyage	14 days, 18 hr. 15 min.
Average economy, gal. per nautical mile	4.46
Average speed, knots	7

From San Francisco to Seattle very heavy weather was encountered. The chief engineer reported that the screw was out of the water half of the time, but no racing occurred at any time, due to the perfect action of the governors.

The engines of the *Libby Maine* are an example of approved European practice adapted to the needs of the Pacific Coast and stand as a milestone of progress in the use of the internal-combustion engine as applied to marine propulsion.

Mechanical Features of Vertical-Lift Bridge

A Veteran Bridge Engineer's Comments on Mr. Van Cleve's Annual Meeting Paper, Together with Details of a Recently Constructed 260-ft. Double-Track Lift Span

By DR. J. A. L. WADDELL, KANSAS CITY, MO.

At the 1918 Annual Meeting a paper of the above title, presented by Mr. H. P. Van Cleve, dealt with the important developments in the operating mechanisms of vertical-lift bridges during the past 25 years, and devoted special attention to structures designed and constructed under the supervision of Dr. J. A. L. Waddell, the eminent bridge engineer and author of treatises on bridge engineering. Dr. Waddell has been good enough to supplement Mr. Van Cleve's presentation by the following additional particulars of some of the structures described in the paper, as well as by details of a new lift bridge at Louisville, Ky., embodying his most recent ideas in design. A comprehensive abstract of Mr. Van Cleve's paper appeared in The Journal of November 1918, p. 938.

MR. VAN CLEVE'S excellent paper has proved of special interest to the writer, who may justly claim to be the father of the modern vertical-lift bridge. His first design, made in 1892, was for a 250-ft. span at Duluth, Minn., to cross the canal which forms the entrance to the harbor of safety for lake vessels in that vicinity. The War Department prevented the building of the structure, but in 1902 permitted at the same location the construction of a *transbordeur.*

Soon after the rejection of his plans for that proposed bridge, the writer was retained to design and supervise the construction of a similar but shorter-span bridge at South Halsted Street, Chicago, the first bridge mentioned by Mr. Van Cleve in his paper. This structure was built under great difficulties and in spite of many discouragements. The Chicago engineers as a body were opposed to this type of bridge; and the then highest authority on bridges in America, the late George S. Morison, stated flatly that it could not possibly operate, and that it would be impracticable to raise the span off the piers. On the strength of this statement the City Engineer, Mr. Geraldine, made all the arrangements for canceling the contract for the construction, although some of the substructure had been completed and a large portion of the metal-work had been manufactured. It took some very earnest pleading by the writer to persuade him to permit the work to proceed; and the said pleading would not have been successful had it not been for an important fact pointed out, viz., that the city of Chicago would have had to pay the full contract price for the structure whether it were built or not.

The specifications called for the lifting of the span to the full height (involving a raise of 140 ft.) in 60 sec.; and, much to the surprise of everybody, on the first trial the span went up in about half of that time. Afterward the writer timed the operation, both up and down, and found that the span could be moved over the full height in 28 sec. This was certainly a great triumph for a comparatively young engineer in a struggle with the local technical body, including the highest bridge authority in America.

Referring to the Keithsburg bridge which Mr. Van Cleve mentions, the heavy-duty, slow-speed gasoline engine used is clumsy, ponderous, and conducive to jar, although undoubtedly effective. It is quite certain that a light, high-speed type, such as the automobile or tractor engine, will prove more satisfactory for future lift bridges.

Fig. 1 Double-Track Lift Bridge of Pennsylvania Lines at Louisville, Ky.

In truth, though, gasoline engines are to be used for lift bridges only as a last resort or as an auxiliary; because electric motors are far superior in every respect. Again, direct-current motors are much more satisfactory than alternating-current motors; and, consequently, they should be used whenever an ample direct-current supply of power is obtainable. The writer is pleased to see that Mr. Van Cleve has called attention to these important points.

Mr. Van Cleve mentions that the heaviest sheaves yet used for any vertical-lift bridge were those for Bridge No. 458 of the Pennsylvania Lines West of Pittsburgh, and that each sheave weighs 31 tons. Within the last few weeks there has been completed for the same railway company a vertical-lift bridge, designed by Waddell & Son, Inc., across the Louisville and Portland Canal that lies adjacent to the Ohio River at Louisville, Kentucky; and the sheaves for this structure weigh 38 tons each.

As this is the very latest thing in lift-bridge construction, the following description of the structure should prove of interest:

The double-track span, which is 260 ft. long between centers of end bearings, weighs about 3,000,000 lb., and is lifted 32.4 ft. in 45 sec. There are 64 counterweight ropes $2\frac{1}{8}$ in. in diameter, passing over the four 15-ft. sheaves. The motive power consists of two 150-hp., 220-volt, a.c., 60-cycle, 580-r.p.m. motors equipped with solenoid brakes. Magnetic control is used. Speed reduction from the motors to the winding drums is made through a train of three sets of spur gears to a cross-shaft having a pinion at each end meshing with two drum gears.

The span is shown complete in Fig. 1 and the operating machinery in Figs. 2 and 3. Fig. 4 shows the operating drums which raise or lower the span and which are quite similar to those used in the Don River bridge in Russia. However, the detail of the cross-shaft has been improved by adding two bearings and two couplings, thus giving more rigid supports for the pinions and making the lengths of shaft between the center main frame and the drum frames truly flexible. This detail eliminates entirely any trouble from errors in the alignment of the three frames, which otherwise would cause considerable friction and loss of power. Hand operation is provided for by two 4-arm capstans.

Fig. 2 Machinery House of Lift Bridge Shown in Fig. 1

There are 16 plow-steel operating ropes, each 1 in. in diameter, the drums and sheaves over which they run being 36 in. in diameter. These ropes work in pairs, i. e., there are two up-haul and two down-haul ropes at each corner of the span. The take-up devices for the ropes are eyebolts threaded over the entire length, with anchorage attachments at top and bottom of towers.

The counterweight sheaves, the heaviest yet built, are constructed of steel plates, angles and castings. In their designing special care was taken to eliminate the troubles which had arisen in connection with the built-up sheaves described in Mr. Van Cleve's paper. Each rim segment is fastened to the side plates by a sufficient number of rivets to take the entire load coming upon it from the ropes; and $\frac{1}{2}$-in. spaces were left between the segments, so that there might be no trouble if the lengths of the segments should overrun. It was originally intended to fill these spaces with hemp; but the cutting tools gave trouble when the machining of the grooves was begun; and it was found necessary to fill them with babbitt. The trouble previously experienced from bad fit of side plates on the hub casting was eliminated by making the said side plates bear directly on the shaft instead of on the hub casting. The hole for the shaft was bored out after the sheave was completely assembled and riveted. The journals are $22\frac{1}{2}$ in. in diameter and 24 in. long, the overall length of the shaft being 7 ft. 8 in. The hub is keyed to the shaft by three keys $1\frac{1}{2}$ in. wide and 1 in. deep, secured from longitudinal movement by set screws. The bearings are lined with phosphor-bronze bushings for high pressure and low speed. Oil grooves are cut into the bushings, the lubricant being supplied from marine-type, screw-feed, compression grease cups.

The rail locks are of sliding-tongue type, standard with the Pennsylvania Lines. The four tongues at each end of the span are driven by a 5-hp. motor. Limit switches are provided to cut off the current at each end of the travel. The controllers for the rail-lock motors are interlocked with the signal system, so that the locks cannot be opened until the signals are set against train movements over the bridge, and so that clear signals for train operation cannot be given until the locks are closed. The controllers are also interlocked with those for the main operating motors so that current cannot be supplied to the latter until the locks have been opened, and so that the locks cannot be closed until the bridge has been seated.

The span is kept in correct position during motion by guide rollers, which roll on vertical guides on the outsides of the tower columns. There are eight rollers for transverse guiding, one at each L_0 point and one at each U_0 point. Longitudinal guiding is effected by two rollers at each L_0 point at the fixed end of the span. There is considerable play in the guides, so as to eliminate any possibility of binding. On account of this play they do not center the span closely enough for the rail locks, which have very little play. For this reason there is placed a transverse centering casting, having very little play, at the middle of each end floor beam. In earlier designs a transverse centering casting was placed at each L_0 point; but considerable play had to be left in these castings to provide for expansion and contraction, and they did not center the span accurately enough for the rail locks.

The train thrust is cared for by two thrust castings, one at each L_0 point at the fixed end of the span.

In order to eliminate jar when the span seats, there are provided air buffers near each end of each of the end floor beams. Adjustable needle valves on the exhaust ports of the buffers enable the resistance of the said buffers to be varied at will.

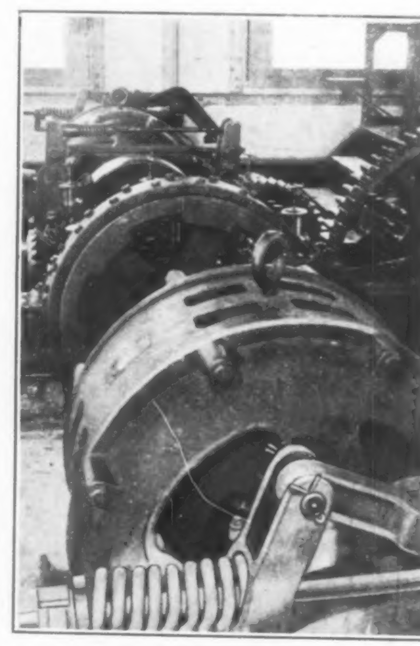


Fig. 3 Motors and Brake Shaft of Bridge Shown in Fig. 1

Bridge locks were not used, but the counterweights were made about six tons lighter than the span, the excess weight of the latter overcoming any tendency for it to rise.

The span can be handled from the machinery house, which is located at the center thereof, or from an interlocking tower on shore about 100 ft. from the south end of the span. It is intended to operate the span from the machinery house until the operators become thoroughly familiar with the manipulation, after which it will be operated from the interlocking tower. Duplicate switchboards, with indicator lamps, meters, etc., are placed in each house. The main switchboards and the resistances are located in the machinery house.

As was stated previously, each motor is equipped with a solenoid brake. In addition there are a hand brake and a motor-operated brake. The lever of the hand brake is in the machinery

house on the span, and gives the operator graduated braking power, so that he can stop the moving mass without jar. The controller of the motor-operated brake, which has three degrees of braking power, is located in the interlocking tower. These braking devices are not of great importance in a slow-moving bridge like this one; but for a high-speed bridge, which will coast for several feet after the current has been turned off, they are much more important.

The erection of the lift span was quite difficult, as traffic had to be maintained over the bridge and navigation could not be interfered with. The old moving span was a swing. It was at first proposed to erect the new span in its fully lifted position. As the counterweights would then have to be built at the lowest point of their travel, it would have been necessary to leave large notches in them for the passage of trains. This scheme was abandoned for that and other reasons, and a new one was worked out. Permission was secured from the United States Government to leave only a 100-ft. channel near the north tower. This channel was spanned by a plate-girder lift span of the same type as the main span, worked by hand-operated crabs. After the main-lift-span towers were partly erected, navigation was stopped for a few hours while one end of the swing span was removed, the gallows frames for the plate-girder-span towers were erected, and the plate-girder span placed in position. The remainder of the swing span was then removed, the towers erected, the sheaves and ropes placed thereon, and the counterweights constructed on falsework resting on the piers and floor beams. The south portion of the lift span was then erected, also the north hangers; and the counterweight ropes were attached. The machinery was erected complete and thoroughly tested out. Navigation was then closed for a day, the plate-girder span removed, the remainder of the lift span erected and riveted, and the operating ropes connected up.

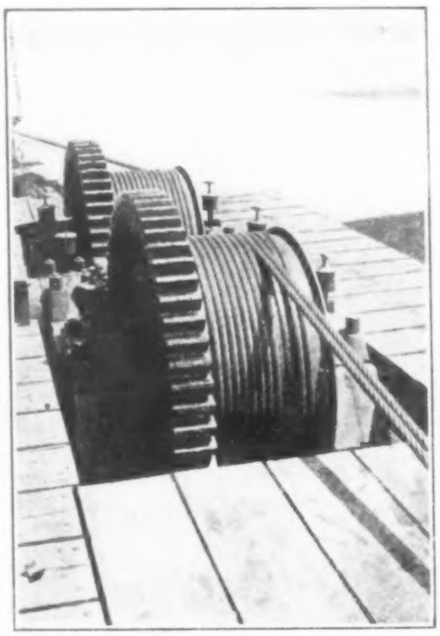


Fig. 4 Upstream Drum of Bridge Shown in Fig. 1

Special care was taken in the aligning of the main-sheave bearings. This was done by means of a steel straight-edge as long as the shaft. The bushings had been scraped to fit the shafts in the shop, the shafts and bushings being matchmarked. The aligning was so carefully done that when the sheaves were hoisted up they fitted perfectly in the bearings, and each 38-ton sheave could be rotated by one man. The machinery and motors were also aligned and tested out very carefully. The motors were run for several hours before the operating ropes were attached to the drums, in order to get the machinery into smooth-running condition and to determine if there were any poorly aligned bearings. Any hot bearings which developed were realigned. The machinery and the electrical equipment were in perfect operating condition before the operating ropes were attached to the drums and before the plate-girder swing span was removed.

Waddell & Son, Inc., has lately designed deflection bearings for main sheaves which insure a uniform pressure over the entire length of the journal. With the high bearing pressure used in the design of journals for lift-bridge sheaves and bascule trunnions this is extremely advisable. The use of this type of support greatly simplifies the problem of aligning the bearings.

One general fault of the electric equipment of movable bridges may be pointed out—that of using too small power lines. The overload capacity of the motors for vertical-lift bridges is called into play if a span becomes unbalanced, and, for bascules, when operating against a high wind; and this requires power lines of ample capacity. This point is not quite so serious in the case of direct-current motors, as the drop in voltage in the power line will merely cause the motors to run slower; but with alternating-current motors the drop in voltage reduces the torque materially, because the torque of such a motor varies as the square of the voltage. For instance, a 10 per cent drop in voltage means nearly a 20 per cent drop in torque. This point requires special attention when the power lines are long.

In spite of all the opposition which the vertical-lift type of movable bridge has encountered in the last quarter of a century (some of it being very bitter and most of it totally unfair), that type has come to stay; and it will be used more and more in the future, after railroad and city officials overcome their prejudice against the use of wire rope and learn that, for economy in first cost, simplicity of design, quickness of operation, rigidity under load, and economy in maintenance and repairs, it is unequaled by any other type yet evolved.

Comments on Dr. Waddell's Communication by Mr. Van Cleve

The writer has been much interested to read Dr. Waddell's comments on his Annual Meeting paper, and also to learn something of the details of the Louisville lift bridge, the only one so far constructed with which he is unfamiliar.

The guiding, centering, and interlocking details described have all been used on previous bridges, but the operation of the span from a point on shore a distance as great as 100 ft. from one end of it, is new and deserves some comment.

To the writer this feature seems objectionable, mainly because it would put the operator somewhat out of touch with the requirements of passing boats, but also because it would prevent that vital contact with the movement of the span which goes a long way toward preventing careless operation. The writer has been present during operation on ten lift spans of this type, sometimes as operator, and sometimes as observer, and he feels that the presence of the operator on the span is, while not absolutely necessary, at least very desirable; and that if it seemed best to have one man operate both the track signals and the lift span, it would be better to place the signal stand on the lift span than the span master controller in the signal tower. This alternative may have been considered in the case under discussion, and found impossible, but it was done very satisfactorily in the case of the C. & N. W. Ry. bridge over the Illinois River at Pekin, Ill. In this installation all track switches and signals are thrown electrically, but this is not necessarily the case, as demonstrated by the fact that at least one of the lift spans now in operation carries on its deck some twenty lines of pipe of the signal system which automatically unjoint at both ends of the span when the latter is lifted.

Referring to Fig. 1 in the paper on The Conservation of Heat Losses From Pipes and Boilers by Glen D. Bagley, published in the November 1918 issue of The Journal, p. 918, the heat loss per square foot per hour, per degree fahrenheit difference, should have been given *without* the decimal points, in the first vertical column.

Properties and Preparation of Glues

Data on the Properties, Preparation, Classification, Grading and Testing of Glues, Strength of Glued Joints, etc., Based on Experimental Work of Bureau of Aircraft Production

GLUE is a subject which has become of particularly great importance since the development of the use of veneer construction in aeronautics, and the following data, abstracted by special permission of the Bureau of Aircraft Production, War Department, from a confidential bulletin,[1] and based on experimental work done in the laboratories of the Bureau at McCook Field, Dayton, Ohio, are accordingly of more than ordinary interest.

Glue is defined as an impure form of gelatine possessing the property of adhesion, which differs somewhat from the popular understanding of the word, which is taken to include all substances having adhesive qualities with the exception of certain types of cements, shellacs, etc. Glue, however, is really a compound consisting of a large proportion of gelatine with certain other substances, such as chondrin, keratin and mucin, associated with it, and, in general, the glue advances in the scale of purity as the ratio of gelatine to the other substances present increases.

Classification and Most Desirable Properties

Glues are classified in accordance with the substances from which they are made, as follows:

1 Bone glues from the horns, raw bones of heads, ribs, shoulder blades, etc., of domestic animals.

2 Hide glues from tannery waste, such as skin trimmings, etc.

3 Sinew glues from the sinews of cattle.

4 Fish glues from fish offals, air bladders and membranes.

5 Casein glues from fermented milk and other milk products.

6 Egg-albumen glues.

7 Blood-albumen glues.

8 Vegetable glues from certain non-nitrogenous vegetable growths, such as Irish or Iceland moss, agar-agar, seaweeds, gums and dextrines.

The above classification includes all the most important groups. Other divisions are possible, such as hot and cold glues, liquid and solid products, etc., but these will be considered later.

The most desirable properties of a glue are:

1 Strong adhesiveness.

2 Tenacity, which is slightly different from adhesiveness, and which may be defined as the power to resist the disruptive effect of a stress in any direction.

3 Elasticity, or the power to stretch slightly without fracture. In this connection the moisture content is a very important factor, as glues which are too dry are often inclined to be brittle. While such glues may stand an enormous stress under a steady load, the sudden application of a comparatively light load is liable to cause failure. The constant vibrations, varying stresses and shocks to which airplane members are subjected make it vitally important to select for airplane construction a glue with a fair amount of elasticity as well as high strength.

4 Covering power. This can be determined by estimating the water absorption, the tenacity of the jelly and the viscosity of a solution of known strength.

5 Practical working qualities. Among the most important properties of glue are its workability in the shop, rapidity of setting, etc.

Casein and Blood-Albumen Glues

The original paper describes the process of manufacture of the various types of glues and the manufacturing elements which determine the properties of the final product. From this point of view the most interesting parts are those referring to casein glues and blood-albumen glues, on which very little printed information is available. The following data are presented in the Bulletin:

When the sugar of milk ferments, producing lactic acid, the milk turns sour, and casein, the characteristic proteid of milk, is separated in a coagulated mass, due to bacterial action. Casein also may be produced by adding acetic acid to fresh milk which has been diluted and warmed. An appreciable excess of acid must be employed, however, as exact neutralization of the diluted milk with acid does not precipitate the casein, owing to the interference of the alkaline phosphates present in the milk.

In the manufacture of casein glue, the commercial casein is purified by alternate solution in alkali and precipitation with acid, the precipitate being thoroughly washed each time. The number of these treatments determines the purity of the product, and hence its price.

Certified casein glue is supplied by the manufacturer in the form of dry powder, the chief constituent of which is the casein derived from milk as just described.

There is not very much information available at present concerning the manufacture of blood-albumen glue. It is made from blood, or from serum albumen resulting from the evaporation of the separated serum of fresh blood. The evaporation is conducted at about 50 deg. cent., and the albumen is obtained in the form of flakes varying in color from grayish to black. Three or four qualities of blood albumen are known, the purest being a dirty yellow and the poorest, black. Similar to the casein glues, the blood-albumen variety is waterproof.

The article gives some data as to the preparation for use and method of application, especially in regard to casein glues. From this it appears that the principal difficulty encountered with the casein glues lies in the rapidity of setting after mixing with water, as it seems they set at periods from 30 min. to 5 hr., depending on the brand.

Strength of Glued Joints

Factors affecting the strength of a glued joint are enumerated in the following order:

In the first place is mentioned the skill of the operator; next, and being of almost equal importance, is the quantity of glue which penetrates into the pores of the wood; and, finally, the avoidance of the formation of air bubbles which frequently cause the failure of a joint. With blood-albumen glues the question of mixing and application, especially as regards temperature, is very important, as the glue does not spread properly if too cold.

In another part of the investigation, referring, however, more specifically to casein glues, the following enumeration of factors affecting the strength of the joint is given:

1 Kind and quality of the wood to be used.

2 Nature of the joint.

3 Quality and condition of the glue.

4 Temperature of the glue, of the surfaces of the joint, and of the surroundings.

5 Hygroscopic condition of the wood.

6 Method of application of the glue.

7 Amount and duration of pressure to be employed.

8 Time and conditions of setting, and subsequent drying of the glued joint.

9 Nature of the strain to which the glue is to be subjected.

A highly interesting section of the paper refers to the subject of testing of glues. This is a matter of considerable difficulty, as

[1] Bulletin of the Experimental Department, Airplane Engineering Division, U. S. A. (Bureau of Aircraft Production, War Department—Confidential), vol. 2, no. 3, December 1918, pp. 5-26, 10 figs., *cpA*.

there are no specific standards for such tests, and the whole subject is on a very indefinite and unsatisfactory footing. In fact, it appears that under one class of test a good glue may show up excellently, while under some other testing method the same material may not indicate nearly as good results.

Testing of Glues

The tests may be divided into two main classes; chemical and physical. The former are of particular value only in special cases. The physical tests appear to be of more immediate value.

The first examination is sometimes instructive. Thus, the odor of the glue affords some indication of its quality, as a glue having an offensive smell is not considered of the highest grade.

The preservative quality of a glue is determined by allowing the jelly left from the jelly strength test, during manufacture, to stand in the laboratory at room temperature for a number of days. The odor and condition of this stock are noted at intervals. Glues with good keeping qualities will stand several days without developing an offensive odor or showing any appearance of decomposition.

The consistency of the jelly test suggested by Lipowitz in 1861 has been extensively adopted for commercial purposes. For this test 5 grams of glue are soaked in water at room temperature and then dissolved in enough water at 70 deg. cent. to make the total volume 50 cu. cm. when cold. The solution is allowed to stand in cylinders ½ in. internal diameter for 12 hr. at 18 deg. cent., and the consistency value of the jelly is then determined by inserting in the jelly a small pointed plunger with a funnel at its upper end, which is gradually loaded with the lead shot until the load is just sufficient to force the plunger entirely through the

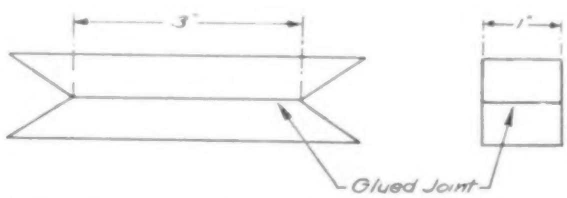


Fig. 1 Joint Used by the British Royal Aircraft Factory for Testing Glues

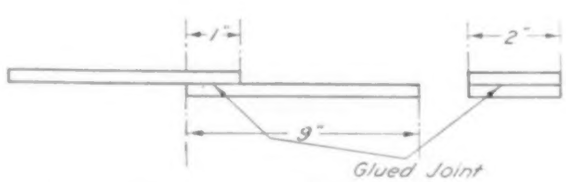


Fig. 2 Standard Test Block Used for Testing Glues by the Aeronautical Inspection Directorate, U. S. Army

jelly from its top surface to the bottom of the cylinder. The weight of shot necessary to effect this gives the Lipowitz number.

At the Aeronautical Inspection Directorate Laboratories a round-ended glass rod is employed instead of a pointed steel plunger, and the results obtained have been found to be more consistent and satisfactory.

The jelly consistency test is usually accompanied by a viscosity determination of glue solutions. The American Air Service criterion, formerly used, that "the strength of the glue in shear shall not be less than that of the wood," is not sufficient, it is stated. A very poor glue could be made to pass the specification merely by selecting for the test wood which was considerably below the average of the species in tenacity. The test may be made unfair by using a wood of unsuitable grain.

The method officially adopted in Germany is the Spandau test, described as follows:

It consists in gluing together with a plain butt joint, end grain to end grain, two blocks of wood 40 mm. in cross-section and 210 mm. long. Glue stock for the test joint is prepared by dissolving 250 grams of glue in 500 cu. cm. of water, and reducing the solution thus obtained to half of its original volume by evaporation. This is done in order to ascertain whether the prolonged boiling necessary to evaporate the solution will have any tendency to reduce the adhesive properties of the glue.

The blocks of wood having been glued together, one is fixed horizontally to a table in such a manner that the joint between the two blocks overhangs a few millimeters beyond the edge of the table. A scale pan is attached to the block a given distance beyond the edge of the table, and weights are placed in the scale pan until fracture of the glue joint takes place.

The British Royal Aircraft Factory has a standard glue test which is a modification of the Spandau method.

According to R. A. F. specification dated Nov. 21, 1916, a double-wedge-shaped test block is made up by gluing together two pieces of black American walnut, as shown in Fig. 1. The glue solution is prepared according to the instructions issued by the manufacturers of the material. Thus made, the test joint, meas-

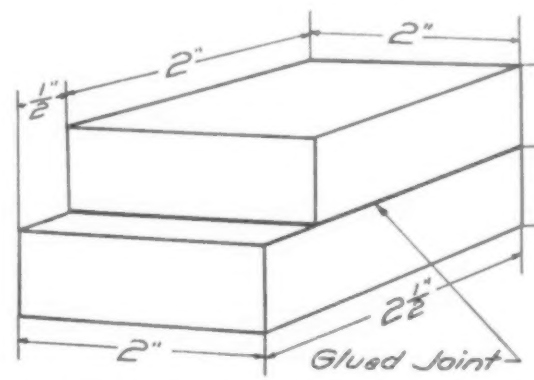


Fig. 3 Test Specimen Described in Bureau of Aircraft Production Glue Specifications

uring 3 in. by 1 in., is required to support a static load of 187 lb. per sq. in. under the following conditions:

1 Dry-heat test. The test piece must support its static load at 122 deg. fahr. for 30 min.

2 Humidity test. It must support its static load in a fully saturated atmosphere for 25 min.

3 Submerged test. The test piece, submerged in water, must support its static load for 36 hr.

It is to be noted that the Spandau test subjects the glue to a combined shear and tensile stress, while by the R. A. F. method a direct tension seems to be intended.

Strength tests conducted by the laboratories of the Aeronautical Inspection Directorate on glue intended for use in the construction of aircraft are unlike either of those methods previously described, and do not appear to afford a measure of any clearly defined physical constant. The disruption of the glue in these tests is more nearly a shear than anything else; but in any case the results have been found in practice to be reasonably comparable.

The procedure adopted in carrying out the A. I. D. strength tests is as follows:

1 Test pieces. Consist of carefully selected pieces of hard, dry American walnut 2 in. wide by 9 in. long and ⅜ in. thick. The flat 2 in. sides are planed true and slightly toothed with a fine smoothing plane. See Fig. 2.

2 Constant temperature. In order to obtain a constant temperature in both the wood and the glue solution under test, a constant-temperature oven, maintained at 35 deg. cent. or 95 deg. fahr., is employed. The wooden test pieces are allowed to remain in this oven for several hours before the test joint is made.

3 Preparation of glue solution. Following the maker's instructions, a weighed quantity of glue is soaked in the required volume of water at room temperature. When thoroughly soaked, which is usually in about 24 hr., the glue is heated in a water-jacketed pot to a temperature of 60 to 80 deg. cent. (140 to 175 deg. fahr.) for ½ hr. The inner vessel or kettle of the glue pot

is then transferred to a constant-temperature oven maintained at 60 deg. cent. (140 deg. fahr.), and is allowed to stay there for about 1 hr., or long enough to bring its contents up to the temperature of the oven.

4 Preparation of test joints. Two pieces of the warm wood are then removed from the oven, and the glue is quickly applied to the faces to be joined, using a finger to spread the glue in order to avoid air bubbles. The two pieces are then pressed together so that they form a simple overlap joint 1 in. long and having a total glued area of 2 sq. in. The details of the joints are given in Fig. 2.

5 Number of test joints. Nine joints, made as above described, are prepared for each sample for glue to be tested. They are clamped for 12 hr. in hand presses, such as are ordinarily used in modern gluing practice. The pressure is then removed and the joints allowed to set for 24 hr. at room temperature.

6 Tests. Three tests are applied to these nine specimens, three being subjected to each of the following tests:

a Regular dry test. Three of the joints are broken in turn by clamping the two ends and pulling the component parts of the joint apart in a testing machine. It is necessary that the load be applied without jerks, and that bending of the test pieces be avoided as far as possible. The load is put on at the rate of about 3000 lb. per min., and the amount necessary to break the joint is recorded.

b Heat test. Three of the remaining six joints are then placed in an oven at 45 deg. cent., and are subjected to dry heat at this temperature for 72 hr., after which they are removed from the oven and broken as above.

c Immersion test. The remaining three joints are immersed for 3 hr. in water at 25 deg. cent. (77 deg. fahr.). On removal from the water they are broken as above.

The three sets of joints are broken on the same day in order that the results may be comparable.

Glues are classified in three divisions by the A. I. D., and in order for a glue to be put into one of these classes it must attain the following values in the tests:

Division.	Breaking point in tests, lb. per sq. in.		
	Regular test	Heat test	Immersion test
Propeller Class	1100	1100	900
Class I	1000	1000	800
Class II	900	900	700

It will be noticed that the best glues are thus retained for propeller work. Class I glues are sanctioned for all important construction exclusive of propellers, while the Class II material is approved for smaller and less important work.

In conducting the above tests it usually is found that the break occurs in the glue, but should the fracture be located wholly or partly in the wood, the result is discarded if the value obtained is below the minimum figure given above.

One other point deserves attention, namely, that the figures given in the table relate to the 2-sq.-in. test joint specified. A larger test joint would not show a proportionate increase in strength. For instance, if the area is doubled, the strength will be increased only about 50 per cent.

Grading of Glues

Interesting data are also presented on the subject of grading of glues, and also on their waterproof qualities. There are several methods of grading glues which, however, are entirely arbitrary. The oldest scheme in use in this country, and which is still generally employed, is the Cooper system, which was originated by Peter Cooper. No rational basis is used in grading glues by this method, the various Cooper grades representing simply those which were put out by Peter Cooper's glue factory, and which, being remarkably uniform, came to be adopted as standards of comparison. The Cooper grades are eleven in number, as follows: A extra, 1 extra, 1, 1X, 1¼, 1⅜, 1½, 1⅝, 1¾, 1⅞, 2. Of these, A extra is the strongest and 2 the weakest.

It is frequently found, however, in attempting to grade different glues by this system that there are varieties which are stronger than the A extra grade, and it is also evident that glues may be of almost any intermediate strength between the various Cooper grades. It is also a fact that a glue corresponding to one of these grades in gelatinizing power may agree with an entirely different rating in viscosity. There is in this respect a marked difference between bone glues and hide glues, and between acid-treated types and those not so treated. For instance, an acid-treated glue may rate as high as 1X in gelatinizing power and as low as 1¾ in viscosity. There are numerous discrepancies of this sort which must be taken into account by the glue tester, so that the rating of glue by this system is full of difficulties.

Relative Merits of Different Glues

The following data on the relative merits of different glues are also of considerable interest. No one best glue has so far been found, since very few records of systematic strength tests are available. Most types of glue suitably selected and manufactured can be made fairly water resistant.

The three kinds of glue suitable for use in airplane construction are the hide, casein and blood-albumen varieties. Of these only the casein and blood albumen types are satisfactory for plywood construction, as hide glue is not truly waterproof. Tests to date show that both these glues can be used to advantage, and it therefore seems advisable to allow plywood manufacturers to apply whichever preparation they prefer.

Since the latest Bureau of Aircraft Production specifications for plywood do not bar the use of any glue, it is very important that the soaking and baking tests be carefully made in order to detect the use of any non-waterproof or otherwise unsuitable glue which might show very great strength if not subjected to deteriorating conditions, but which would lack the necessary lasting qualities.

Hide glue has so far been very satisfactory for propeller construction, provided sufficient care be taken to properly guard against moisture and changes in atmospheric conditions. Casein glue may eventually prove more satisfactory for this use, however.

Blood-albumen glue is not altogether suitable for general work, except in the manufacture of plywood, on account of the care and expense necessary in its use, the hot presses and other costly equipment required, etc. Its high strength and waterproof qualities, however, make it excellent for laminated construction. Blood-albumen glue has been found to be even more water-resistant than the casein types.

For general airplane use, including splices in spars and longerons, plywood and built-up members, casein glue seems to offer the most advantages. It is nearly as strong as the best hide glues, while it is comparatively waterproof, is fairly easy to mix and apply, and is quite dependable if proper care is exercised.

The original paper contains a list of manufacturers of glues, with addresses, and a short bibliography on the subject.

LUBRICATION OF AIR COMPRESSORS[1]

SATISFACTORY lubrication of air-compressor cylinders is attained by securing (1) the reduction of friction to a minimum and (2) elimination of carbonization of the oil as far as possible.

Carbonization of the oil allows the accumulation of deposits of carbon which are sticky in the early stages of their formation but hard and flinty later. Such deposits accumulate on the cylinder valves, in the cylinder passages, in the pipes and eventually in the air receiver.

Sticking or partial closing of the valves and their consequent failure to act properly is probably the chief objection to this action from the standpoint of the efficient operation of the compressor.

The formation of excessive carbon deposits is apt to be due to any one or more of the following causes:

[1] From a report prepared by H. V. Conrad, 30 Church Street, New York, Secretary of the Compressed Air Society, and issued by the Technical Committee of that society.

1 The ill-advised use of some oil, such as a steam-cylinder oil, which easily decomposes in the heat of the air cylinder.

2 The use of oils of too great a viscosity—commonly referred to as "too heavy oils." These do not atomize readily and, therefore, remain too long upon the hot cylinder walls, etc., thus baking down to sticky carbon deposits.

3 The use of too great quantities of oil, which has the same effect as the use of too heavy an oil as far as the carbonization is concerned.

4 The failure to provide a proper screen over the air intake of the compressor, thus allowing free entrance of dangerous dust (especially coal dust).

Heat of Air Compression. The selection of an air-cylinder lubricant, of course, is governed to a considerable extent by a knowledge of the cylinder temperature it must withstand. Knowing the air pressures, the corresponding temperatures are ascertained fairly accurately, as shown in Table 1. This table gives the final temperature in the cylinder at the end of the compression stroke, for single-stage, also for two-stage (or compound) compression, when the free air entering the cylinder is at 60 deg. fahr.

TABLE 1 CYLINDER TEMPERATURES AT END OF PISTON STROKE

Air Compressed to (pounds, gage)	Single-Stage, Final Temperature, deg. fahr.	Two-Stage, Final Temperature, deg. fahr.
10	145	....
20	207	....
40	302	....
60	375	203
80	432	224
100	485	243
150	589	279
200	672	309
250	749	331

The natural inference after noting the temperatures in Table 1, is that an air-cylinder oil should be selected whose flash point is higher than the maximum temperature apt to be encountered within the air cylinder. As a matter of fact, this is not the case.

Qualities of Cylinder-Lubricating Oils. For average normal conditions, the oil should be a medium-bodied pure mineral oil of the highest quality, not compounded with fixed oils such as animal or vegetable, and should be carefully filtered in the final process of manufacture. A distinction must be made between those oils having a paraffin base as distinguished from those having an asphaltic base. Carbon deposited by the asphaltic-base oils is of a light, fluffy nature and easily cleaned out, whereas, that deposited by the paraffin base oil is very adhesive, and characterized by the hard, flinty nature.

Paraffin-Base Lubricating Oils. Merely as a guide to aid the operator in specifying the qualities to be possessed by an air-cylinder lubricant recommended for average duty, Table 2 is presented.

It is suggested that those oils within the range expressed by the minimum figures be used for light duty of low pressures and temperatures, while those expressed by maximum figures should be used for high pressures and temperatures.

It is recommended that any paraffin-base lubricant intended for use in "all standard air compressors," should meet the physical tests imposed by the average range of figures given in the middle column of Table 2. The above wording "standard air compressors" is to be interpreted as including the following types of machines:

a Low-pressure up to 100-lb. compressors, which may be either small-sized single-stage units, or larger-sized compound machines.

b High-pressure compressors which are constructed with the proper number of stages so that no excessive temperatures are ever reached.

TABLE 2 PHYSICAL TESTS OF PARAFFIN-BASE OILS

	Minimum	Average	Maximum
Gravity, Baumé ..	28 to 32 deg.	25 to 30 deg.	25 to 27 deg.
Flash Point, Open Cup............	375 to 400 deg. fahr.	400 to 425 deg. fahr.	425 to 500 deg. fahr.
Fire............	425 to 450 deg. fahr.	450 to 475 deg. fahr.	475 to 575 deg. fahr.
Viscosity (Saybolt) at 100 deg. fahr.	120 to 180 sec.	230 to 315 sec.	to 1500 sec.
Color............	Yellowish	Reddish	Dark Red to Green
Congealing Point (pour test, deg. fahr)............	20 to 25 deg. fahr.	30 deg. fahr.	35 to 45 deg. fahr.

In other words, this lubricant of average test figures is always recommended unless a compressor manufacturer specifies in his literature that a high-flash-point oil should be used to meet the conditions peculiar to his machine. It is thus obvious that it is never necessary that a lubricant should possess a flash point as high as 500 deg. unless abnormal conditions of high temperature prevail. Such high-flash-point oils have an unusual tendency to produce carbon deposits.

Asphaltic-Base Lubricating Oils. This group of oils is considered separately for the reason that the lower limit of gravity stated in Table 2, viz., 25 deg. Baumé, eliminates the entire group from consideration—which is not the intention. As a guide for the selection of suitable oil, Table 3 is given.

TABLE 3 PHYSICAL TESTS OF ASPHALTIC-BASE OILS

	Minimum	Average	Maximum
Gravity, Baumé...	20-22 deg. fahr.	19.8-21 deg. fahr.	19.5-20.5 deg. fahr.
Flash Point, Open Cup........	305-325 deg. fahr.	315-335 deg. fahr.	330-375 deg. fahr.
Fire............	360-380 deg. fahr.	370-400 deg. fahr.	385-440 deg. fahr.
Viscosity (Saybolt) at 100 deg. fahr.	175-225 sec.	275-325 sec.	475-750 sec.
Color............	Pale Yellow	Pale Yellow	Pale Yellow
Congealing Point (pour test)......	0 deg. fahr.	0 deg. fahr.	0 deg. fahr.

Proper Quantity of Lubricating Oils. The quantity of lubricating oil to feed to the air cylinders of compressors cannot be stated in exact terms due to the varying viscosity of different oils, the heat of compression and the size of cylinder. It may be stated in general, however, that after the cylinders have acquired smooth and polished surfaces, the quantity should be reduced to the lowest limit to avoid the possibility of the accumulation of carbon and sooty deposits.

TABLE 4 QUANTITY OF AIR-CYLINDER LUBRICANT REQUIRED PER 10 HOUR DAY

Diameter of Cylinder, Inches	Size of Cylinder, Inches	Displacement per Minute, Cubic Feet	Piston Speed, Feet Per Minute	Sq. Ft. of Cylinder Wall Swept by Piston	Drops Oil per Minute	Drops Oil per 10 Hr.	Sq. Ft. Oiled Per Drop	Number Pints Oil Required Per 10 Hr
8	8 x 8	120	344	718	1	600	718	0.0375
12	12 x 12	320	408	1230	2	1200	613	0.0750
18	18 x 18	880	496	2340	4	2400	585	0.1500
24	24 x 24	1730	550	3450	6	3600	575	0.2250
30	30 x 30	2940	600	4700	8	4800	590	0.3000
36	36 x 36	4550	644	6070	10	6000	607	0.3750
42	42 x 42	6700	696	7600	12	7200	633	0.4500

Figures of last column are based upon an estimated 16,000 drops per pint of oil at 75 deg. fahr.

The basis of quantity given in Table 4 is recommended, subject to above modifications for these cylinders or equivalent sizes, operating under normal conditions.

A leading authority on compressor engineering contributes the following: "The best way to determine the proper amount of lubrication is to take out the valves from time to time and examine the cylinder. All parts should feel that there is oil thereon. If they feel dry, the lubricators should be adjusted to feed a little

more oil, whereas if oil lies in the cylinder and its parts show excessive oil thereon, the quantity fed by the lubricators should be reduced. By thus examining the machine a few times, the proper amount of oil can be determined to suit the characteristics of the particular lubricant used and the conditions under which the machine operates." This is a better way to finally determine the quantity of oil required than by adopting without this experimenting any tabulated number of drops.

BOILER CODE COMMITTEE

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York City.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in The Journal, in order that any one interested may readily secure the latest information concerning the interpretation.

Below are given the interpretations of the Committee in Cases Nos. 208-214, inclusive, as formulated at the meeting of January 17, 1919, and approved by the Council. In this report, as previously, the names of inquirers have been omitted.

Case No. 205

Inquiry: An interpretation is requested of the distinction between the term *staybolt* and the terms *stay* and *brace* as used in the A.S.M.E. Boiler Code. Under what conditions may a reinforcing member be considered a *staybolt*, or a *stay* or *brace?*

Reply: The term "staybolt" as used in the Boiler Code refers to a bolt screwed through the plate or plates, with the ends of the bolt riveted over or fitted with nuts.

Case No. 207

Inquiry: Is it the intention of the Boiler Code Committee that in the application of Par. 214, item (1) means that the radius of the flange is not to exceed eight times the thickness of the head, or that d is so limited while the radius may be as large as desired?

Reply: It is the intention of the Committee that the restriction implied in Par. 214 shall apply only to item (1).

Case No. 208

Inquiry: Is it permissible under the requirements of the Boiler Code to use extra heavy steel pipe for superheater drum of a header type boiler, this pipe drum being connected to a steam drum by tubes which form part of the boiler heating surface?

Reply: Under the requirements of Pars. 9 and 11, the header or drum under discussion must be of wrought steel or cast steel of class B Grade. It is the opinion of the Committee that the words "wrought steel" in these paragraphs, mean wrought steel in accordance with one or the other of the specifications for various classes of wrought steel that are incorporated in the Code.

Case No. 209

Inquiry: If it becomes necessary to change the setting of a safety valve by putting in a new spring, what is the procedure necessary in connection with the marking on the body of the valve? Also in the case of a boiler whose total safety-valve area exceeds that of the orifice of the nozzle by 25 per cent, is it necessary to put on a larger nozzle to accommodate this safety-valve capacity? The owner points out that if they could substitute flat-seated valves, the present nozzles would be amply large.

Reply: If a safety valve is fitted with a new spring which changes its relieving capacity, it is the opinion of the Committee that it should be considered as a new valve which will necessitate remarking. In the case of two safety valves whose total area exceeds that of the nozzle by 25 per cent, it should be understood that if this applies to the case of an existing installation, the requirement of Par. 278 of the Boiler Code is not applicable; to a new installation, on the other hand, the requirement of Par. 278 is applicable and cannot be modified.

Case No. 210

Inquiry: An interpretation is requested of Par. 328 of the Boiler Code with regard to its applicability to soot-blower doors in the settings of water-tube boilers where the doors are made 8 by 8 in. in size and are seldom located less than 10 or 12 ft. from the floor.

Reply: In specifying latching devices for firing doors, furnace inspection doors and clinker doors in Par. 328, it was the intent of the Boiler Code Committee that all outward-opening doors, excepting explosion doors, shall be latched, unless they are so located that the attendant will not be injured by an explosion of the gases or tubes within the boiler setting.

Case No. 211

Inquiry: Is it the intent of Par. 277 of the Boiler Code to prevent the use of a connection to a spool or Y-pipe between the boiler and the safety valve for supplying steam to soot blowers which are subject to only occasional use? It is pointed out that such a connection would avoid an extra opening in the steam drum.

Reply: It is the opinion of the Boiler Code Committee that there should be no auxiliary connection of any sort made to the fitting between the boiler and a safety valve, if there be any such fitting.

Case No. 212

Inquiry: An interpretation of Par. 274 is requested which will show whether the safety valves should be proportioned with capacities as rated in Table 8 (Table 15, Edition of 1918) to relieve the total steam generated by the boiler, or of an arbitrary rating per sq. ft. of heating surface.

Reply: The sizes of safety valves should be determined on the basis of the total relieving capacity, the minimum value of which is to be determined in accordance with Par. 274 and on the basis of the relieving capacity of the safety valves stamped thereon by the manufacturer. Table 8 (Table 15, Edition of 1918) does not govern the relieving capacity of safety valves, but simply shows the computed relieving capacity for various lifts of safety valves. There is no limit set in the Code to the amount the safety valve may lift, provided the valve operates properly, and it may be that the relieving capacity stamped on the valve by the manufacturer will be greater than any of those given in Table 15.

Case No. 213

Inquiry: Can vertical tubular boilers up to 54 in. in diameter which are built of flange steel with punched rivet holes, drilled tube holes and cast-iron fire-door ring and mud ring, be stamped under the A.S.M.E. Boiler Code standard when the operating pressure does not exceed 50 lb.?

Reply: The boilers referred to in the inquiry, if used as steam boilers, may carry 15 lb. pressure as a maximum under Par. 338 of the Boiler Code, or if used as hot water boilers, may carry 50 lb. pressure as a maximum under Par. 335*a* and *b*. If, as steam boilers, they carry more than 15 lb. pressure or as hot water boilers, they carry more than 50 lb. pressure, they must conform to the Rules for Power Boilers.

Case No. 214

Inquiry: In the case of a gas-fired vertical-tubular boiler which is so encased that the products of combustion pass outside of the shell as well as through the tubes, is it permissible under Par. 430*d* and *v* to locate the fusible plug in the outside shell?

Reply: The fusible plug may be placed in the shell of a boiler of this type where the hot gases pass around the shell, provided the height of the plug corresponds to that it would occupy if placed in the tube as specified in Par. 430*d*.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of MECHANICAL ENGINEERING by members of The American Society of Mechanical Engineers are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in this journal, or brief articles of current interest to mechanical engineers.

Improvements in Locomotive Boilers

TO THE EDITOR:

In the Engineering Survey Section of MECHANICAL ENGINEERING for March, pages 284 and 285, I notice a description of certain improvements in locomotive boilers which were recently tried out on the Chicago, Milwaukee and St. Paul Railroad by Mr. Nicholson. As I have been a designer and constructor of all kinds of boilers for a great number of years, as well as the designer and builder of tools for making boilers—having equipped practically two-thirds of the boiler shops in the United States with my tools—I am sufficiently interested in the subject-matter of the abstract in question to submit the following comments:

1 Pockets in fireboxes are not new, but their connection with the leg of the boiler, where all the mud and dirt is supposed to collect, is a new idea. Presumably this has been suggested by the arch tubes which have been placed in boilers with a view of improving circulation and for accommodating the brick arches. This connection, I believe, will prove difficult and costly to maintain.

2 Locomotive boilers some years ago were very much smaller than they are today, and their present abnormal size makes it very difficult to control expansion and contraction, two great evils in connection with rigid firebox construction which railroad men have been trying to control with flexible stays instead of flexible fireboxes.

3 The desirability of placing obstacles in fireboxes to save fuel is questionable, and the fact that the construction described is installed where the heat in the firebox is greatest proves how valuable firebox heating surface is. The application of this idea requires a construction of greater rigidity than that of the ordinary firebox, and rigidity, it is agreed by all boiler experts and engineers, is the cause of all the troubles in fireboxes. It is also to be noted that a greater number of stays have been added to the firebox, which, I may state, is very undesirable.

Should this arrangement be generally adopted, I predict it will prove a very costly experiment to the railroads; the Government is not warranted in allowing such ideas to be made to appear practical when it is known by experts that the advantages it affords are obtainable only at the expense of its upkeep. It is well known, too, that the locomotive is already loaded up with more improvements than the upkeep warrants.

WILLIAM H. WOOD.

Media, Pa.

Labor Dilution as a National Necessity

TO THE EDITOR:

The Great War has been the means of educating the masses in things that are vital to the nation, and of the many important projects which have come to our attention, the training of semi-skilled and unskilled labor in the arts of manufacturing has become a necessity that all are bound to recognize.

Before the War very few manufacturers had any idea of the meaning of Labor Dilution. What does this Labor Dilution mean? In so many words it means the utilization of the army of misfits into productive industrial units. Except as applied to female workers, Labor Dilution has hardly had a fair start, notwithstanding the immense amount of constructive work that has been done through the Army and Navy instruction centers.

The Curtiss Aeroplane and Motor Corporation was one of the first to appreciate the value of maintaining a school for the purpose of training our female workers on exactly the same operation they would be expected to perform in the production departments. The success of this work is evident to all employers who have recently used women on operations formerly performed by male labor. They have made good, and it is the universal opinion that on many jobs women are better than men.

Will industry, now that it understands what results can be accomplished by Labor Dilution, revert to the old state of affairs? I think not. We have been accustomed to measure our needs by the other fellow's experience, but now it is plain to us it is not necessary to strive for the high standards of mechanical ability we have heretofore demanded.

For years we have overlooked a valuable source of labor supply right at our doors simply because we had no means of utilizing their labor. We have neglected to study the mental progress of semi-skilled and unskilled laborers. We have, without thinking, assigned them to the laboring positions, never giving them the benefit of an ambition to aspire for advancement.

During the past year our experience has been that men who formally applied for laboring positions were asking for machine jobs. In questioning them we found they had no special experience to qualify them for the important positions, and the result was that many of them were turned away. However, in the aeroplane business it was not possible for us to draw from an available supply of expert aeroplane mechanics, and there were operations where we could take some of the brightest applicants and place them on work where they could, in a short time, master the details.

In looking back we recollect with amazement the avidity these men and women displayed when they were given a chance to break the bonds which held them in check. They have played an important part in the battle for liberty because they themselves have become liberated, and now that the war is over, are they to become an industrial asset or liability?

These men and women have had the benefit of specialized industrial training, and while they are not full-fledged mechanics, they are, nevertheless, better equipped to qualify for industrial work. The next question is, Are they going to be able to capitalize their experience? Naturally one would say, "Yes, if they can find the same class of work." I do not think this has any bearing in the case, because these people have demonstrated to their own satisfaction that if they can learn one job they can learn another. If this is not true, then is not all the study and work that has been put into labor dilution been in vain?

The force of habit in some concerns is bound to manifest itself in the readjusting period now before us. They are going to cast about for the high-grade skilled mechanic in the thought that they are going to beat their competitors in the rush for peace-time business. The wise manufacturer, however, will "father" the idea of building an organization of operators which can be very easily developed by intensive training methods.

For instance, large employers of labor throughout the country, who, for the past year or more, have spent a lot of time and money on intensive training, are not going to set this all aside and proceed to hire and train their operators by the old methods. It is not necessary to prove to them how much it costs to replace workmen taken into the shop and turned over to a foreman on production work for instructions under the old system. This is by far the most expensive way, figuring it from all angles.

In the Curtiss Aeroplane and Motor Corporation we have found that it costs, on an average for a three months' period, \$34.27 to

train a girl or woman for production work. It is reasonable to assume that if the worker was placed in the shop without going through the training department, the cost would be two or three times as much.

The soldiers and sailors who have been trained intensively in the various technical schools and manufacturing plants throughout the country, are they going back to their old line of endeavor, or are they going to follow the work in which they have been instructed? Again the theory of labor dilution must be upheld or else the efforts which have been put forth to train these men have been wasted.

For example, the Navy has periodically sent batches of men to our plant to receive intensive training in the construction of flying boats. Many of these men never had a woodworking tool in their hands before, but in a short time were able to perform a very creditable job, so much so that they were able to make all necessary repairs without outside assistance.

These men have received a training they never would have acquired under normal conditions. They have "found" themselves and are not going back to the old pursuits. Industrially these men are an asset, and as such we are duty bound to provide them a means of livelihood.

The part that organized labor will play in this scheme must necessarily wait developments, but we must not overlook the fact that Samuel Gompers, President of the American Federation of Labor, is the motive power which called into being the committee on Training and Dilution, responsible for the propaganda of specialized industrial training.

Even before the war employment managers were unanimous in the statement that there was a shortage of qualified mechanics. Manufacturers and employers of labor generally were responsible for this state of affairs, because when there was a mechanical position to be filled they demanded an A1 man for the job. We had long since given up the practice of the indentured apprenticeship, and it was not so much the question of where the man received his training as it was to get the right man. The idea of doing their part in replacing and developing the inevitable loss of expert mechanics due to old age and death did not concern them until the war came, and their best men either enlisted or were drafted into the Army and Navy. It was then the necessity of labor dilution manifested itself. Industry and the workers have benefited by the introduction of intensive training methods, and it is not reasonable to suppose they are going to turn their backs on a system which has enabled the Government to provide the sinews of war. We have taken a step forward which does not permit retraction.

Charles E. Fouhy,
Employment Manager,
Curtiss Aeroplane and Motor Corporation.

Buffalo, N. Y.

Industrial Service Education

To the Editor:

At the Thirty-ninth Annual Meeting of The American Society of Mechanical Engineers, Mr. D. R. Kennedy, Employment Manager of the American International Shipbuilding Corporation, expressed in a splendid way the changed conditions in industry as follows:

"Permit me to prophesy that the executive of the next decade will be the man who best knows men. He will be an organizer, a handler of men as individuals, a handler of men in the mass, a leader, not a driver; a very human man. The science of human engineering is here to stay. The study of human characteristics is the most enduring, as well as the most fascinating, in the world, and still the most complex."

The big question is, How are we to develop this new type of engineer, manager, employer, business executive? Some of these men will be self-made. A large proportion of them will probably come from among the graduates of our engineering schools and colleges. This raises the really fundamental question, To what extent are our engineering colleges giving the type of instruction which will tend to build this new type of executive? It is encouraging to see that, from a rather comprehensive study of practically all the important engineering colleges of the country, many of these are beginning to readapt their curricula to include more on the human side of the job. Much more of this must be done. A thorough investigation of engineering education made by C. R. Mann, of the Carnegie Foundation for the Advancement of Teaching, revealed clearly this need. The Industrial Service Movement of the Young Men's Christian Association has been responsible for a suggested college course on the Human Side of Engineering, which includes such studies as the following: The Human Factor in Industry, Human Factors in Production, The Ethics of Engineering and Business, Employment Management, Vocational Guidance, Scientific Management in Its Human Relations, The Engineers' Responsibility for Service, and Industrial and Social Readjustment and Reconstruction. (Copies of this course and bibliography will be furnished on request.) Already a number of leading institutions have adopted this, or a similar course, in whole or in part.

Remarkable results have attended such courses wherever given, but even this is not enough. With this fact in mind, the Y. M. C. A. has, for over ten years, been promoting a thoroughly comprehensive scheme for the education of our coming engineers in the human side of their work. In addition to counseling with leading employers, labor men, engineers and professors throughout the country, and suggesting helpful courses of study, the organization has worked out, in its Industrial Service Movement, helpful lists of lecturers, lists of books and welfare literature, a series of pamphlets intended to inspire the engineering student and graduate along lines of industrial betterment and service, etc. The movement has enlisted as many as 4500 college students from over 250 engineering schools and universities, in fifty varieties of worth-while service with working men and boys. About 2000 of these students have taught classes in English, citizenship and Americanization. Approximately 1000 others have led technical classes and taken charge of other lines of work with American workingmen, and the rest have been helping with boys' clubs and other forms of constructive endeavor among working boys and apprentices. The amount of actual service rendered has been extraordinary, and 100,000 industrial workers have been reached. The quality of the service has been surprisingly high, and the appreciation of the men served very great. Needless to say, however, the students themselves have gained far more then they have given. They have inevitably come to understand actual industrial conditions and the problem of handling men whom they will be obliged to handle after graduation. Their practical service has given them a sympathy and understanding which could be gained in no other way.

Under normal conditions our colleges are graduating approximately a thousand men a year who have had a real touch with this movement, and who, from all probability, scatter throughout the industrial world into larger spheres of influence. Whatever their occupations, they will never cease to be human engineers. This is the big objective. It will be these men, and others like them, together with many of our returned soldiers, upon whom the burdens of industrial and social reconstruction will fall.

Fred H. Rindge, Jr.

347 Madison Avenue, New York.

In a pamphlet on International Control of Minerals recently issued by the U. S. Geological Survey, the strategic position of the United States is graphically shown by a table compiled by Dr. C. K. Leith. The United States controls about one-third of the world's mineral production of 1,700,000,000 tons. The few minerals for which this country is dependent on foreign countries are offset by so many in which we have a dominance of supply and our financial position is so strong that it appears certain that in this respect our entrance into a league of nations would not be based on self-interest. The interests of conservation clearly require an international control of minerals; whether the time has come to establish a league of nations with economic control, he says, can be determined only by the collective answers to the question of whether the nations are willing to make the necessary economic sacrifices in the interest of world harmony.

ENGINEERING SURVEY

A Review of Progress and Attainment in Mechanical Engineering and Related Fields, as Gathered from Current Technical Periodicals and Other Sources

AERONAUTICS

Balancing Aeroplane Propellers (Baudisch, *Der Motorwagen*, December 20, 1918). A perfectly balanced propeller has its center of gravity exactly on the center line of the propeller shaft on which it rotates. In practice, although the propellers are made out of wood, as homogenous as possible, and the two blades are nearly identical as can be attained, one blade is invariably heavier than the other.

The balancing of the propeller to make the center of gravity of the propeller coincide with the center of gravity of the propeller shaft can be done either statically or dynamically. The method of procedure for the static balance only requires simple appliances, but is very tedious and slow to carry out.

The dynamic balance can be done much more quickly, but it requires a rather complicated and expensive balancing machine, and in consequence the static method is in more general use than the dynamic.

The author proceeds to explain a dynamical balancing process built up on the same principles as the statistical method, which is such that while the results are as exact as those obtained statically, it has the great advantage of being rapid in execution. An additional point is that the apparatus required is as simple as that for the static test.

The propeller is fitted to a horizontal testing axle, which rotates on ball or roller bearings so that it is as frictionless as possible. The bearings are rigidly mounted sufficiently high above the floor level to allow the propeller to rotate freely. If the propeller be left to itself it will after several vibrations, come to rest with the center of gravity in its lowest position. The weight which must be added to obtain the true balance can be obtained mathematically by following out a simple system of calculation given by the author, the data for which are gained from the results obtained by fixing known weights both above and below the propeller center, at different given distances.

The article is concluded by some hints on errors to be avoided in making the tests, such as insuring that the testing axle has no bend in it through the weight of the propeller, that the propeller does not slip on the axle, and that the bearings on which it runs are perfectly rigid. (*Technical Supplement to the Review of the Foreign Press*, vol. 3, no 4, Feb. 18, 1919, pp. 128-129, no. 4308)

AIR MACHINERY (See Heating and Ventilation)

ENGINEERING MATERIALS

Toughness: Its Nature and Measurement

Static, Dynamic and Notch Toughness. According to the author, the point of view presented in the paper here abstracted is that toughness, like hardness or tensile strength, should be regarded as an independent property and of sufficient importance to require, in so far as that may be possible, quantitative determinations. If so, it becomes necessary to devise experimental means for measuring or valuating toughness and the notched-bar impact

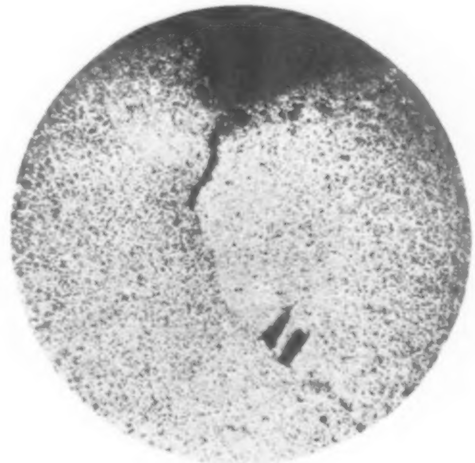


Fig. 1 Left Side of Keyseat

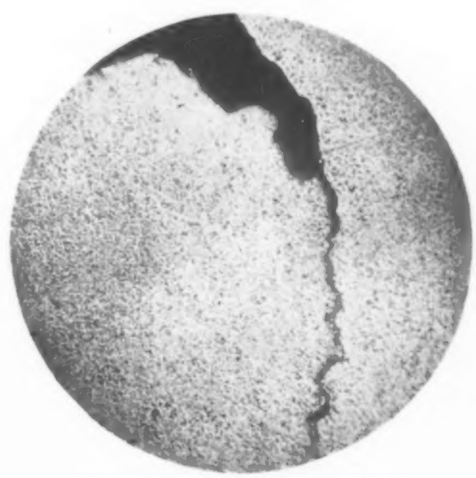


Fig. 2 Right Side of Keyseat

test or the Charpy test is advanced as the most logical test that has so far been developed for this purpose. It is also claimed that there are two kinds of toughness, which have to be dealt with independently.

Tough materials have been defined as those that offer consider-

able resistance to permanent deformation, but which, once resistance has been overcome, may be deformed plastically, though only by the expenditure of considerable energy. In other words, tough materials may be deformed plastically, but they absorb a considerable amount of work in the process. This kind of toughness may be called "static" when the rate of loading is reasonably slow, or "dynamic" when the rate of loading is comparatively rapid, as in the impact test. In all cases the stress distribution is essentially uniform, but static toughness does not imply resistance to shock, or dynamic toughness; and dynamic toughness may be equal to, greater than, or less than static toughness, a fact illustrated by numerous cases on record.

In addition to the foregoing there is what the writer calls "notch toughness," defined as the ability of a material to withstand stresses when in the notched condition. (It is a well-known fact that if the change in cross-section is in the form of a nick or a groove, the strains at the base of the nick multiply and are much greater than the average strain over the cross-section.)

Attention is called to the fact that the notch effect is quite frequently met with in engineering practice. At times it may be intentionally introduced through the design of the part, sometimes faulty, and at times may be unintentionally introduced through faulty or careless workmanship. It is also important to consider the microstructure and the desirability of heat treatment as a means of overcoming or counteracting the effect of the notch.

Several examples showing the danger of the presence of notches in various forms are considered, among others being the danger of a keyseat in an axle. Photomicrographs, Figs. 1 and 2, are given showing the extensions of two cracks leading from the angles of the keyseat. If it is necessary to use such a keyseat, the material should be suitably heat-treated to give a high notch toughness, or better, perhaps, both the material and the heat treatment should be selected with reference to its notch toughness.

The writer recommends that a notched-bar test should supplement the usual tensile and hardness test and its results be used as an index of the resistance of the material to the notch effect.

Objection has been raised to the adoption of such a test on the basis of lack of uniformity of results. In a number of cases the results of the notched-bar impact test are not as concordant as might be desired, but it is the opinion of many experimenters that variations in the impact resistance of supposedly similar test bars are due to actual variations in the material. The truth of this contention is demonstrated by the recent work of Charpy and Cornu-Thênard, who, by using exceptionally uniform and homogeneous bars, secured check results as close as 1 to 2 per cent and scarcely ever varying as much as 4 per cent. The results obtained by the commission of the German Society for Testing Materials were sufficiently concordant to lead to the adoption of the test and the minor variations were not permitted to mask the fact that the notched-bar test is capable of yielding valuable information that the tensile strength does not.

The writer is informed that at least one steel plant, which has done considerable work on the notched-bar test including the Charpy test, has found the concordance of results to be very satisfactory and capable of yielding possible differences of impact resistance of the order of magnitude of 1:30. Thus, it would seem that lack of concordance can now no longer be advanced as an objection to the adoption of the Charpy test. (*Bulletin of the American Institute of Mining Engineers*, no. 146, Feb. 1919, pp. 339-351, 10 figs., *epA*)

TESTS ON CONCRETE (*Beton und Eisen*, December 4, 1918). Concrete test pieces (8-in. cubes) for the purpose of ascertaining safe crushing loads were prepared in porous and alternatively in iron molds. Those from the latter proved much inferior to the former.

The Government Testing Station in Berlin-Lichterfelde has therefore proposed that test pieces should be prepared in porous molds. Wooden molds were found unsatisfactory, as they did not retain their shape, but plaster-of-paris molds gave good results.

Test pieces prepared from one volume of cement and four volumes of carefully graded conglomerate mixed with 12 per cent of water failed under a pressure of 3400 lb. per sq. in. when made in plaster molds, and under 2235 lb. when made in iron molds, thus showing an increase of strength of 54 per cent in favor of porous molds. Similarly, one part of cement to six of conglomerate failed under 2025 and 970 lb. per sq. in., respectively, showing an increase in strength of 107 per cent. A large number of test pieces have been prepared in molds of iron, wood and plaster of paris, and it has been conclusively proved that the latter are the most reliable, and produce results closely approximating those obtained from test pieces cut out of actual work.

The German Concrete Institute has therefore framed the following regulations:

1 Iron molds as generally used for concrete are unsuitable for concrete grout because water is retained in the concrete and reduces the strength.

2 Molds of wood saturated with oil are also unsuitable. Molds of porous wood give satisfactory results, but must not be used more than five or six times, as they soon become saturated.

3 Plaster-of-Paris molds give test pieces that correspond closely to concrete found in structures. Each side of the plates may be used four or five times without losing the power to absorb water. They are cheap, and large numbers can be made simultaneously. The values found for crushing loads are reliable, and the progress of solidification is regular and in definite proportion to test pieces made in iron molds. (*Technical Supplement to the Review of the Foreign Press*, vol. 3, no. 4, Feb. 18, 1919, p. 109, no. 4192, *e*)

DEFINITIONS OF CEMENT (*Zeitschrift für angewandte Chemie*, December 3, 1918). The short descriptive word "cement" is usually understood to mean portland cement, composed of hydraulic lime and sand. But recently other substances have been substituted for the sand, so that some wider definition is required. In Germany the three now much-used types are thus defined: (1) Portland cement, consisting of a hydraulic binding substance, with less than 1.7 parts to one by weight of soluble silica, plus clay and oxide of iron; and manufactured by fine grinding and intimate mixing, burning, and again grinding; (2) ferro-portland cement, a hydraulic binding substance, consisting of at least 70 per cent portland cement and at most 30 per cent of blast-furnace slag; and (3) blast-furnace cement, a hydraulic binding substance, which, with a portland-cement content of not less than 15 per cent, consists mainly of blast-furnace slag, which, by sudden cooling of the molten mass, is converted into the granular form. (*Technical Supplement to the Review of the Foreign Press*, vol. 3, no. 4, Feb. 18, 1919, p. 109, no. 4191, *t*)

HEATING AND VENTILATION

Ventilating Fan with Air-Reversing Arrangement

MINE VENTILATING PLANT. Description of a British mine-ventilating-plant installation with an engine of 300 b.hp. The most interesting features are the general arrangement at the air end and the connection between the engine and the fan.

At the fan end of the crankshaft there is a flange forged on solid to which a small flywheel is bolted. The latter forms part of a flexible coupling (Fig. 3) which acts as a driving medium for the fan. On the fanshaft there is another similar wheel and between these two wheels there is a fanshaft about 2 ft. 6 in. over all with a flange forged solid on each end. On these flanges are bolted two steel plates which, near their outer peripheries, are bolted to the two flywheels. The arrangement forms a flexible coupling and the reason for employing it is to provide for any slight settlement such as sometimes occurs on a colliery pit bank and might, if not allowed for, cause trouble with the bearings.

A special arrangement shown in Fig. 4 is provided by which the air instead of being abstracted from the mine and discharged into the atmosphere may be driven in the reverse direction. In the left-hand view of the figure the plan is shown sucking air from the mine and delivering it to the atmosphere through the discharge opening or evasee. In order to reverse the direction of flow the discharge door shown at the bottom of the evasee and

counterbalanced by a cord and weight is drawn up so as to close the orifice at the base of the evasee, as shown in the right-hand view of the illustration. At the same time inlet doors in the casing (shown in the plan views at the bottom) are swung from the position shown in the left-hand view into that shown in the right-hand view which has two effects. It closes the passage leading to the inlet from the line shaft and opens the fan section to atmosphere. Then since the air cannot be discharged through the evasee, it is forced by the fan through the opening leading to a discharge passage into the mine which has been uncovered by

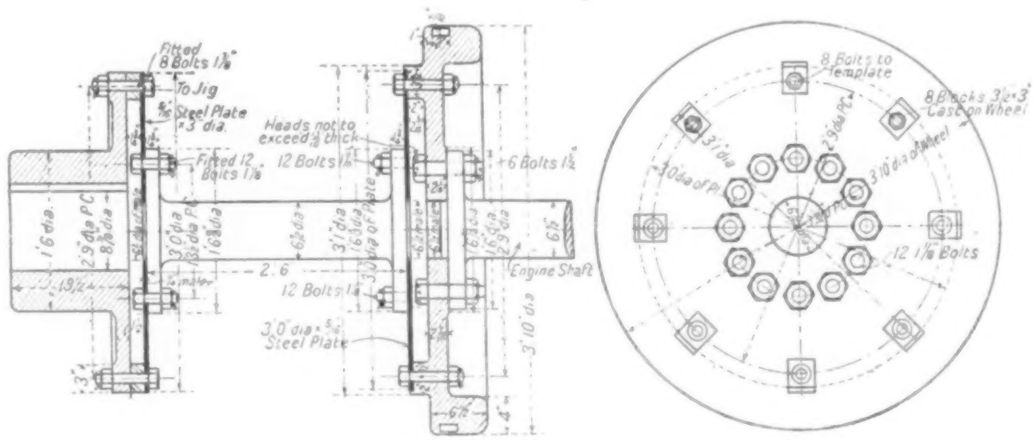


FIG. 3 FLEXIBLE COUPLING BETWEEN ENGINE AND FAN

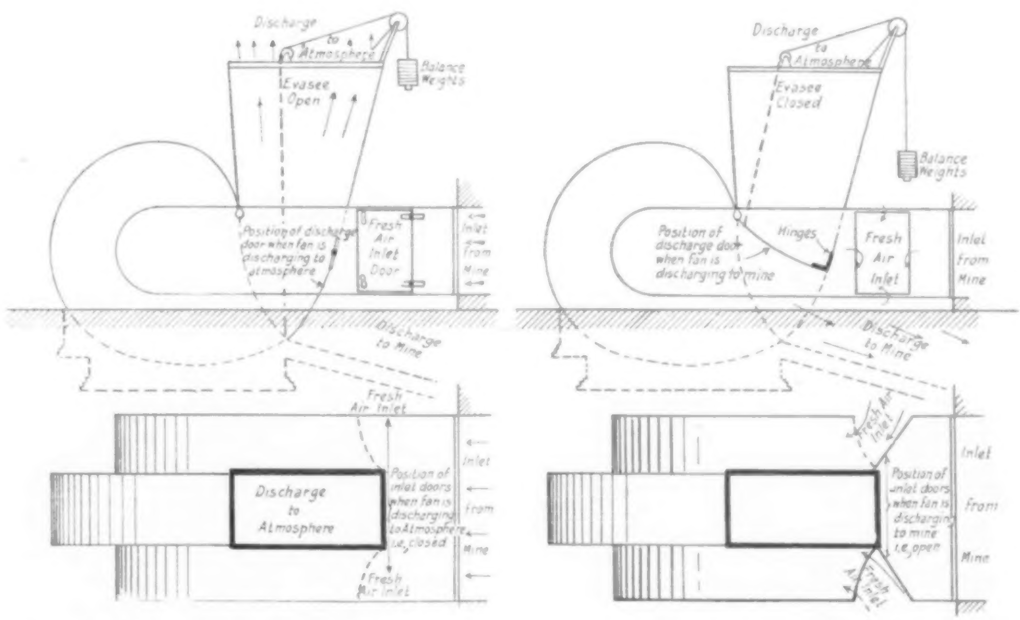


FIG. 4 ARRANGEMENT FOR CHANGING DIRECTION OF FLOW OF AIR IN A MINE-VENTILATING PLANT

the raising of the discharge door. It is stated that the necessary changes to bring about these reversals can be effected without stopping the engine it being only necessary simply to slow the fan slightly. (*The Engineer,* vol. 127, no. 3292, Jan. 31, 1919, pp. 110-111, 6 figs., *d*)

HEAT-TREATING

HARDENING AND TEMPERING CERTAIN RAILWAY MATERIALS (*Stahl und Eisen,* December 5, 1918). G. Schultz, in *Organ,* describes the hardening processes to which keys, bolts, brake rods, parts of springs, screw nuts, valves and other moving parts of railway rolling stock are subjected. For all such parts basic Martin steel with at most 0.12 per cent carbon is used. The pieces are packed in the usual way into sheet-iron boxes, in which the surfaces to be hardened are in close contact with some hardening material. The closed and airtight boxes are kept, according to the thickness of the hardened outer skin required, from 10 to 18 hours in a muffle furnace at a temperature of 900 to 1000 deg. cent. Pieces, of which only a portion is to be hardened, are so packed that only those surfaces which are to be acted upon are in contact with the hardening materials, while the other portions are protected by some ready means. When the heating has been sufficient, the pieces are taken out and cleaned with a wire brush, and while still at a good red heat quenched in cold water. This gives a very hard skin; but, as a consequence of the long heating, leaves the metal coarse-grained and brittle. The quality of this hardened skin is greatly improved by a second heating at 800 deg. and quenching. By this process a fine grain is produced, and increased tensile strength is given to the hardened zone. In the case of important parts of the valve connection of locomotives, the good effect may be increased by several repetitions of the process. The duration of the repeat heats is from 15 to 90 min., according to the sectional dimensions of the piece. Such parts, as cranks and crankpins, which require long heating, are protected from burning by a thin covering of the hardening powder in an asbestos envelope. (*Technical Supplement to the Review of the Foreign Press,* vol. 3, no. 4, Feb. 18, 1919, pp. 112-113, no. 4213, *p*)

HYDRAULIC ENGINEERING

SINGLE-WHEEL COMPOUND WATER TURBINES AND MULTI-STAGE CENTRIFUGAL PUMPS, H. Baudisch. (*Zeits, ges. Turbinenwesen*, 1 and 2, 1918. *Elektrot. u. Maschinenbau*, 36. p. 422, Sept. 15, 1918). Very narrow Francis turbines yield unsatisfactory efficiency. The lower limit of runner-wheel entrance breadth to runner-wheel entrance diameter is from 1/15 to 1/20, corresponding to a specific speed of about 60 r.p.m. There is a range of applicability of the Francis slow runner and that of the free-jet high-speed runner, the highest specific speed of which with single nozzle is about 35 r.p.m. This gap is filled by the Pfarr compound turbine in which water flows in series through several runners on one shaft. It is claimed that better results can be obtained at lower capital cost by allowing the water to flow twice or more through the same wheel. The guide and outlet chamber are divided into two equal parts. Half of the guide equipment is connected to the high-pressure pipe and half of the outlet chamber to the turbine suction pipe; the second half of the outlet chamber is connected to the second half of the guides. This single-wheel compound turbine has 100 per cent higher specific water volume than the Pfarr turbine and the same specific speed. It can be built as an axial or radial turbine or as a combination type; it can also be built as a spiral turbine with the spiral for each stage over one-half of the runner wheel. The use of a double-sided outlet on the runner wheel overcomes the axial thrust of the axial-radial turbine. Taking the lower limit of the specific speed of a runner wheel to be 60 r.p.m., the specific speed of the Pfarr compound turbine is 35.7 r.p.m., of the single-wheel compound turbine, 25.2 r.p.m.; and of the single-wheel, double-sided-outlet compound turbine, 35.7 r.p.m. Certain conditions which must be fulfilled by the single-wheel compound turbine, particularly in respect to pulsation, are noted in the original. The converse of the single-wheel compound turbine is the single-wheel multi-stage centrifugal pump. Both of these machines are of special importance where low capital cost rather than maximum efficiency is the primary consideration. Also, space is saved by the reduced axial length. (*Science Abstracts*, Section B—Electrical Engineering, vol. 22, pt. 1 (no. 253), Jan. 31, 1919, p. 8, *e*)

INTERNAL-COMBUSTION ENGINEERING

Performance of Marine Diesel Engines

TESTS OF MERCHANT-SHIP-TYPE DIESEL ENGINES. Data of official trials of two 1200-i.hp. (750-b.hp.) Diesel engines built by J. Samuel White & Co. for the British Admiralty. The trials were carried out in accordance with the special requirements of the British naval authorities and in the presence of their representatives.

The engines are direct reversible, two-cycle, single-acting, stepped-piston type, six-cylinder, 14½ in. bore by 24 in. stroke, and have a weight complete of 70¼ long tons.

The trials of the first engine consisted of 96 hr. of uninterrupted running at the full load of 750 b.hp. at a speed of about 200 r.p.m.

During the whole trial the engine ran satisfactorily without any stoppage and without any sign of overheating either in the cooling system or working parts. The exhaust was quite invisible and very little soot was observed after the completion of the trial. The temperatures at the end of the trial were practically the same as those attained at the end of the first hour.

The circulating water was passed through the engine by steam pumps, the quantity per brake horsepower being approximately 11.2 gal.

Additional maneuvering trials were carried out with the port engine consisting of astern running, time taken to pump up the starting reservoirs, slow-speed running and the drop in pressure of the starting air after each start.

Table 1 is representative of the results obtained in the 96-hr. trial of the starboard engine, while Table 2 gives data on lubrication and also the heat balance of the engine. (*Motorship*, vol. 4, no. 3, March 1919, pp. 17-20, illustrated, *eA*)

TABLE 1 DATA ON 96-HR. TRIAL OF STARBOARD ENGINE

Mean b.hp.	751.8
Mean r.p.m.	190.5
Mean i.hp.	1215.6
Mechanical efficiency, per cent	61.84
Total revolutions for 96 hr	1,097,307
Total lb. of fuel oil used during 96 hr	35,205
Fuel per b.hp. per hr., lb	0.487
Total lubricating and cooling oil used for 96 hr., lb	887.7
Mean lubricating and cooling oil per b.hp. per hr., lb	0.0123
Mean temperature of cooling water, inlet, deg. fahr	61.5
Mean temperature of cooling water, outlet, deg. fahr	99.5
Mean temperature of piston oil cooling, inlet, deg. fahr	90
Mean temperature of piston oil cooling, outlet, deg. fahr	125
Atmospheric temperature of test shop, deg. fahr	61.5
Injection air pressure (mean), lb. per sq. in	1000
Scavenge air pressure (mean), lb. per sq. in	7
Air Compressors:	
I.P. air cooler pressure (mean), lb. per sq. in	127
L.P. air cooler pressure (mean), lb. per sq. in	27
Circulating cooling water pressure (mean), lb. per sq. in	5
Piston cooling and lubricating oil pressure (mean), lb. per sq. in.	61.56
Compressor suction open, per cent of total	5.35
Mean indicated pressure of No. 1 cylinder, lb. per sq. in	110
Mean indicated pressure of No. 2 cylinder, lb. per sq. in	106.7
Mean indicated pressure of No. 3 cylinder, lb. per sq. in	108.4
Mean indicated pressure of No. 4 cylinder, lb. per sq. in	103.4
Mean indicated pressure of No. 5 cylinder, lb. per sq. in	117.0
Mean indicated pressure of No. 6 cylinder, lb. per sq. in	102.5

Blast air used per b.hp. = 0.22 cu. ft.

TABLE 2 DATA ON LUBRICATION HEAT BALANCE OF ENGINE

	Lb.	Oz.
Oil for power and scavenge pistons and L. P. compressor pistons	80	0
Oil for crankshaft and valve gearing	112	0
Oil for piston cooling and bearing lubrication	693	0
Total	885	0

(i.e., 0.22 lb. per hour or 0.0123 lb. per b.hp. per hr.).

HEAT BALANCE

Calorific value of fuel, B.t.u. per lb	19,510
Consumption per b.hp. per hr., lb	0.487
Consumption per i.hp. per hr., lb	0.303
b.hp. = 751.8, i.hp. = 1215.6 } Mech. efficiency, per cent	61.84

$$1 \text{ b.hp.-hour} = \frac{33{,}000 \times 60}{778} = 2550 \text{ B.t.u.}$$

1 b.hp. requires 1.62 i.hp., therefore frictional

$$\text{Heat per b.hp.} = \frac{0.627 \times 33{,}000}{778} \times 60 = 1578 \text{ B.t.u.}$$

$$\text{Heat taken in per b.hp. per hr.} = 19{,}510 \times 0.487 = 9500 \text{ B.t.u.}$$

$$\text{i.hp. heat units per b.hp.} = \frac{1.62 \times 33{,}000}{778} \times 60 = 4120 \text{ B.t.u.}$$

	B.t.u.	Per cent	
Heat converted into work on brake	2550	26.9	} .. 43.5 per cent
Heat lost in engine friction	1578	16.6	
Heat converted into indicated work	4120	43.5	} .. 100 per cent
Heat lost in cooling water	2480	26.1	
Heat lost in exhaust gases	2900	30.4	
Heat taken in per b.hp. per hour	9500	100.0	

Thermal efficiency of engine = 26.0 per cent

MACHINE DESIGN

Tests on Crankshaft Lubrication

INTERMITTENT-OIL-FEED INVESTIGATION. Data of tests intended to determine the relations between quantity, pressure and seepage in bearings under various operating conditions, and a description of a special testing apparatus set up at McCook Field, Dayton, Ohio, for the present work.

The general appearance of the testing apparatus is indicated in Figs. 5 and 6. Essentially, the apparatus consists of a section of shaft of the same size as the main-bearing portion of the Liberty-12 crankshaft and mounted in a special test bearing with various sizes of inlet and outlet, as well as provision for driving the shaft and for making various measurements. The shaft used in most of the tests was 2⅝ in. in external diameter with a 1¼-in. hole drilled through its center, except at the driven end, which was left solid. The bearing housing consists of a special casting with bearing liner of standard construction. On one side there are four oil inlets *A*, *B*, *C* and *D*, Fig. 6, and opposite to these but staggered with relation to them, there are four outlets A_1, B_1, C_1 and D_1, all equipped with individual stopcocks so that any combination of the inlet and outlet sizes can be used and proper arrangements made for measuring the flow as to quantity (tank *F*), pressure (inlet gage *J* and outlet gage *L*), and

temperature (inlet thermometer N and outlet thermometer P).

In addition to the four side outlets there is an end outlet, shown at E, which takes the oil direct from the center of the hollow shaft and delivers it to a drainage tank I in which the quantity passing through the center of the shaft can be measured. The thermometer O indicates the temperature at this outlet.

The inlet connection M on the top of the test bearing is used in experiments to determine seepage along the length of the bearing. This inlet is located approximately one-third of the length of the shaft from one end and outlets are provided at the ends of the bearings (G and H) leading direct to separate drainage tanks in which the amount of oil seepage at each end of the bearing can be measured.

The oil is supplied to the various inlets under air pressure which can be varied from 25 to 100 lb. per sq. in. The oil line between the supply tank and the inlets is surrounded for part of its length by a steam coil which is used to regulate the temperature of the inlet oil. The test apparatus is water-jacketed to provide means for controlling the temperature of the oil in the bearing itself during the tests.

The first set of tests was made to determine the quantity of oil passing through the bearing under various conditions of shaft speed, inlet pressure, size of inlet openings, etc. These tests were again divided into several series, of which the first dealt with measurements of the quantity of oil that passes through the different sizes of inlet holes and out the center of the shaft at various speeds and inlet pressures.

In these tests it was found that the quantity of oil passing through the bearing decreases with speed and that the decrease is much more rapid in the range from 250 to 1000 r.p.m. than

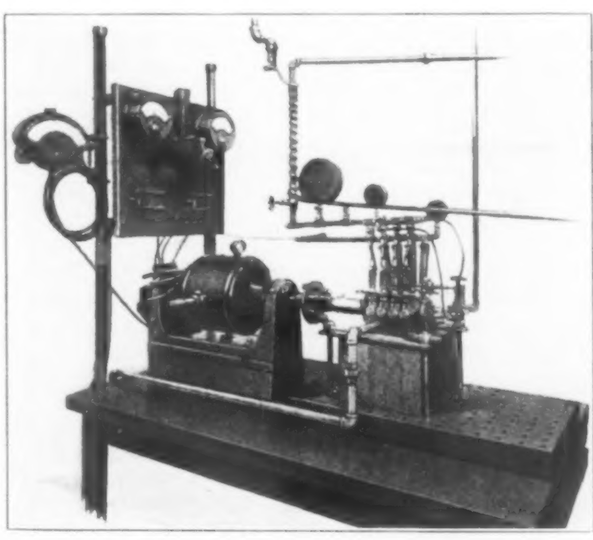


FIG. 5 GENERAL VIEW OF DYNAMOMETER FOR OIL-FEED TESTS

between 1000 and 2000 r.p.m., the curves having a more gradual slope at the higher speeds. As the latter represent normal engine speeds, an effort has been made to derive an empirical formula to cover oil flow in this range.

It was found that the quantity varies directly as the product of the pressure and the inlet-hole area. That is, when the area of the inlet hole is halved, the pressure must be doubled in order to obtain an equal quantity of oil at any fixed speed.

The formula derived from the results of these tests is as follows:

$$Q_b = \frac{1810\ (PA)}{S} \quad \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

where Q_b = quantity of oil in gallons per hour
P = inlet pressure in pounds per square inch
A = area of inlet hole in square inches
S = speed of shaft in revolutions per minute.

This formula may be slightly low with high pressures and large inlet holes, but it is substantially correct when the product of pressure and inlet-hole area does not exceed 5.

The next series of tests dealt with the quantity of oil flowing through the shaft from side inlet to side outlet; that is, through the inlet holes designated as A, B, C and D in Fig. 6, through the hollow shaft and out through the outlets A_1, B_1, C_1 and D_1 at various speeds and inlet pressures.

Centrifugal force set up in the oil inside the shaft complicates the problem of establishing a formula for the quantity values

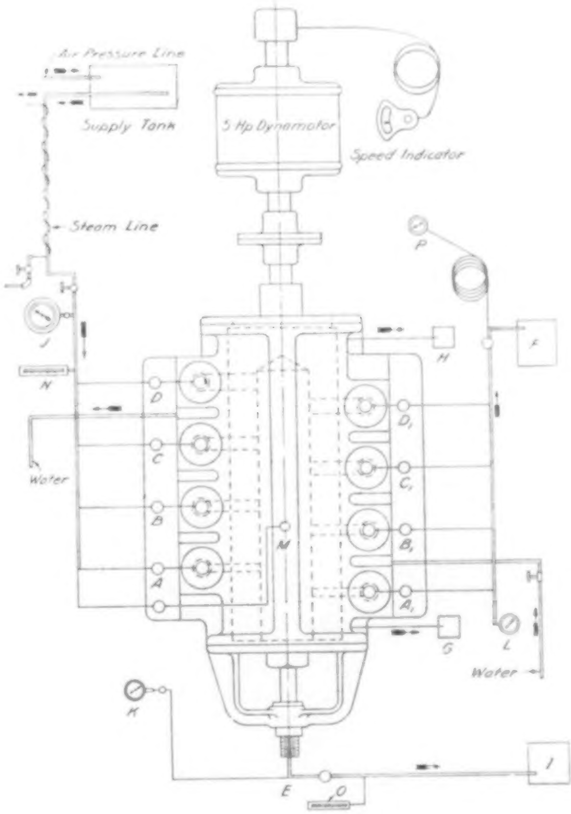


FIG. 6 DIAGRAM OF INSTALLATION FOR OIL-FEED TESTS

obtained in these tests. The data of tests are presented in the original paper in the form of curves, in which, however, it is said that only the parts referring to speeds between 1000 and 2000 r.p.m. should be taken into consideration owing to the more abrupt character of the curves at lower speeds.

A formula to cover all cases has been derived from these tests, namely:

$$Q = \frac{1810\ (PA)}{S + \dfrac{6.9}{A_1}} \quad \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

where Q = quantity in gallons per hour
P = inlet pressure in pounds per square inch
A = area of the inlet hole
A_1 = area of the outlet hole
S = r.p.m. of shaft

Formula [2] is of the same form as the previous one. It may be used to cover all quantity calculations, because if it is considered that there is no outlet hole when the oil is not taken from the side of the shaft, A_1 becomes zero, and although not mathematically correct, it may be considered as canceled out, thus leaving the equation as it was first given. Values obtained with this formula do not in all cases correspond exactly with the results obtained in the tests, but they will be found to be sufficiently accurate to cover the entire quantity range in all ordinary design considerations.

An interesting series of tests were made to measure the amount

of seepage which took place around two special solid shafts used for this purpose. The results of these tests are summarized in the original article as follows:

1 The amount of seepage increases with the speed of shaft
2 The amount of clearance of shaft, within the usual range, has very little effect on the amount of seepage at normal speeds and pressures
3 The amount of seepage varies approximately inversely as the distance of the entering oil from the end of the shaft, being changed principally by the pressure
4 The amount of seepage varies directly with the inlet pressure.

An unusual result obtained in the two seepage tests was that in every case the seepage was greater with the smaller amount of clearance, which is quite contrary to expectations. This condition is difficult to account for, and it may be that it is peculiar only to the test apparatus used.

The effect of the distance through which the seepage must pass also was not according to expectations, and at lower speeds apparently was affected greatly by the amount of shaft clearance. For pressures of 40 lb. per sq. in. and over, the ratio of the seepage at the two ends G and H was practically the same for both shafts. The pressure seemed to play a part in the seepage ratio as between G and H, in that usually at pressures below 60 lb. per sq. in. the ratio was less than 2 to 1, but became larger as the pressure and speed increased, being as high as 3 to 1 at high speeds.

Tests were also made to determine the pressure inside of the shaft when the oil was led into any of the connections A, B, C and D. These tests have shown that the measured pressure in the hollow center of the shaft varies directly as the inlet pressure and also as the diameter of the inlet holes instead of as the area, as in the case of the quantity tests. Another conclusion drawn from these tests is, that with constant inlet pressure and a given size of inlet the drop in pressure due to speed increases more rapidly at high than at low pressures.

A formula has been derived from the data of these tests which provides mathematical means for determining the pressure in the hollow center of the shaft when the conditions are known. It is as follows:

$$p = \frac{5\ (PD)}{\sqrt{S}} \qquad [3]$$

where p = oil pressure inside shaft
P = inlet pressure
D = diameter of inlet hole
S = r.p.m. of shaft.

This equation will be found approximately correct from 500 to 1500 r.p.m. Above the latter speed it may be slightly in error, giving results as much as 4 per cent for each 100 r.p.m. above 1500.

Similar tests were made to determine the pressures at the side outlets of the bearing and it was found that the results corresponded in a general way with those obtained in the previous tests except that they were somewhat higher, so that the formula for pressure outside outlet is of the same form as [3], except that the coefficient is 6.8 instead of 5.

The final series of tests was conducted to determine the intermediate pressures for those in the center of the shaft with oil passing through from either of the side inlets to any one of the side outlets. When oil passed freely through the shaft the pressure in the hollow center portion varied considerably and did not follow any simple rule. In general, however, it was found that the internal pressure increased with the inlet pressure and also with increase of the size of the inlet hole, and decreased with increasing speed. Further, the drop in pressure due to speed is greater with the higher inlet pressures.

The original article is accompanied by a number of interesting curves. (*Bulletin of the Experimental Department, Airplane Engineering Division,* Bureau of Aircraft Production, War Department (Confidential) vol. 2, no. 3, December 1918, pp. 122-142, 18 figs., *eA*. Abstracted by special courtesy of the Bureau of Aircraft Production, War Department).

MACHINE TOOLS

Automatic Arresting Motion for Power Presses

Automatic Arresting Motion for Power Presses. Illustrated description of a mechanism developed in England which it is claimed can be applied to that type of machine in which a flywheel revolves freely on its shaft until a positive connection is established between the two parts by rocking the spring-pressed rolling pin or bolt into engagement with the longitudinally recessed key or striking piece extending the entire length of the flywheel hub, this rolling pin or bolt being usually either kept in engagement so that the intermittent movement of the slide is continued or automatically disengaged after each complete revolution so that the slide may be stopped at its highest point after each single stroke. The inventors have provided an automatic mechanism whereby the slide might be brought to rest at the bottom of the down stroke, in addition to stopping at the highest part of its stroke. The holding at the bottom of the stroke is intended primarily to give the article being stamped a longer period in which to assume the desired form while still under pressure in the dies.

Referring to Fig. 7, A is the side frame of the press, and B the slide-operating shaft upon which the flywheel C revolves freely, until a positive connection is established between them through the spring-pressed trip lever D^1 rocking the rolling pin or bolt D of the shaft B into engagement with the longitudinally recessed key or striking piece E of the flywheel C, all of which are of ordinary construction.

In the invention under consideration there are fixed to the side frame of the press over the shaft B a bracket F having bearings G carrying a bar H formed with a tappet lever J, and being connected by means of a lever K to the upper end of a rod L of an eccentric M mounted on a countershaft N carried in bearings O of a bracket P, which is also attached to the side frame of the press. To the frame, too, but below the shaft B, is a fixed bracket Q, having bearings R carrying a bar S formed with a tappet lever T, and being connected by means of a lever U to the lower portion of the rod L. Rotary motion is imparted to the countershaft N from the flywheel C through the medium of chain gearing V, the chain wheel V^1 of which is loosely mounted on the countershaft N. The chain wheel V^1 is adapted to be locked to the countershaft N at will, through the medium of a slidable clutch W mounted on the countershaft.

On the countershaft N being driven by the chain gearing V the eccentric M has the effect, through the medium of the rod L and levers K U, of rocking the bars H S in their bearings G R, so that the two tappet levers J T are alternately rocked into the path of the spring-pressed trip lever D^1 of the rolling pin or bolt D, so as to cause the shaft B to be disengaged from the flywheel C twice during each revolution of the said shaft, the first disengagement being effected when the slide is at the highest point of its upstroke, and the second disengagement at the time the slide is at the bottom of its downstroke. The ratio of the chain gearing V and the action of the eccentric M may be proportioned as to give any desired amount of dwell to the slide to suit the work to be performed. For instance, with a 3 to 1 gear, such as is that which is fitted to the machine shown in Fig. 0, one revolution of the flywheel C would give a single reciprocation to the slide, while each of the other two revolutions would be rest periods for the slide at the top and bottom of its stroke respectively.

The countershaft N is fitted with a brake block X which is pressed upon by a spring, and which serves to arrest the movement of the shaft when it is thrown out of gear by the clutch W. The tappet-carrying bars H S are also fitted with springs H^1 S^1 for absorbing the shock set up when the trip lever D^1 strikes the tappet lever J T. (*The Engineer*, vol. 127, no. 3293, February 7, 1919, p. 135, 2 figs., *dA*)

MARINE ENGINEERING (See Internal-Combustion Engineering)

MECHANICAL PROCESSES

New Process for Casting Formed Tools

Davidson Process of Casting Formed Tools, J. E. Johnson, Jr., Mem.Am.Soc.M.E. The production of formed tools such as milling cutters, large drills, countersinks and other shapes from high-speed steel by methods hitherto known is an expensive operation. First, a blank of suitable size must be produced by forging an ingot or large bar. After forging, the rough blank is annealed and then sent to the toolroom for machining. This must be done with great care and accuracy and usually involves a multiplicity of operations, since, for example, the formation of each tooth in a milling cutter involves several cuts.

The notable features are three: First, the extraordinary freedom from blowholes; second, the fluidity of the metal; and third, the entire absence of coarse crystallization anywhere in the casting.

In regard to the first of these features, it may be stated that the foundry ran for several weeks before the completion of its baking oven, pouring the steel largely into green-sand molds, and yet made satisfactory tools, there being only a few steam holes near the surface. Since the drying oven was put into operation, blowholes of any description are practically unknown. In regard to the second, the metal, instead of having a comparatively ropy pour, is thin and fluid—more like hot cast iron than like steel. As a result the details of small cutters are cast practically perfect.

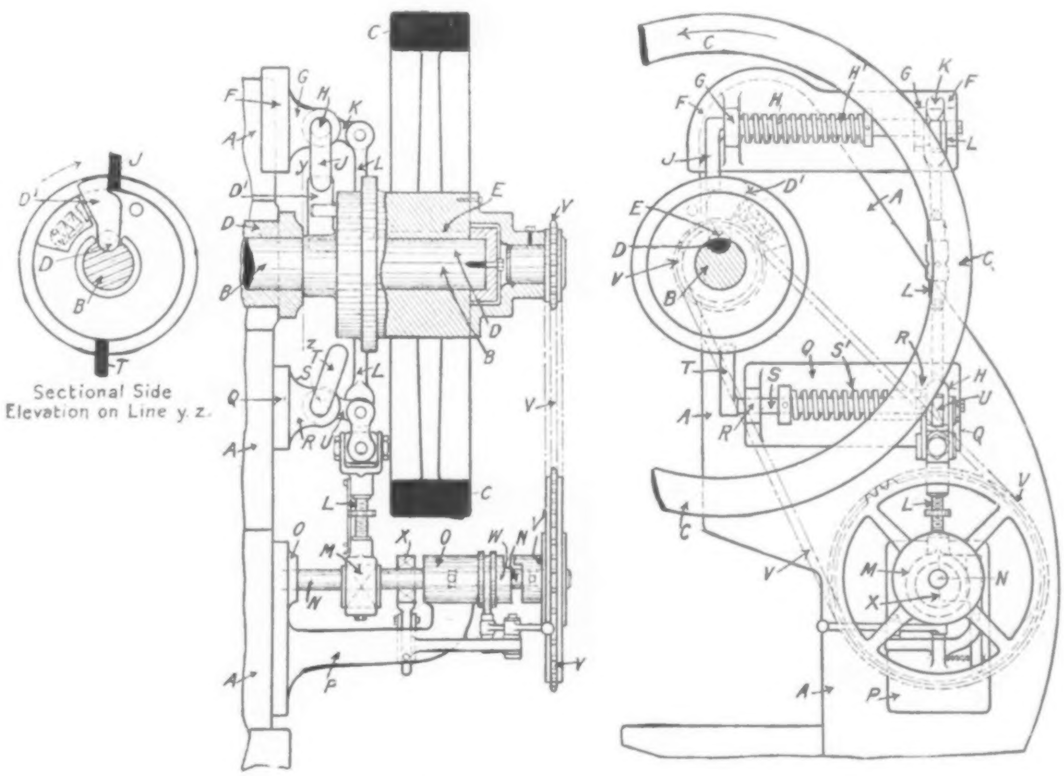


Fig. 7 "White Glove" Automatic Arresting Motion for Power Presses

Various processes have been tried for casting tools to shape in the last two or three years and it is understood that one large manufacturer has such a process in more or less regular commercial use. There are three difficulties with this process from the point of view of ordinary steel-melting practice: (1) That of getting the steel killed so dead that it will be free of blowholes as cast; (2) that of producing a metal fluid enough to flow into the fine parts of the mold and give sharp, true castings. (If this cannot be done, only the rough cuts in machining the cutters are saved and the difficulty involved in cutting the scale may easily offset this gain); (3) that of producing a satisfactory structure to give great endurance and long life to the steel without the refining of the grain, which is often considered to come only from the forging operation.

A new direct casting process has been developed by A. C. Davidson with the assistance of Mr. Johnson, the author, and this is described in the paper and certain data on the history of the development of the process are presented.

From what is stated in the paper it appears that milling cutters are cast with a projecting lip on the cutting edge. This is finished entirely by grinding and with little more expense than the grinding of a machined tool. A perfect edge is obtained in this way with a minimum of labor and lost steel, while the possibility of local defects is avoided.

The material used for killing is a secret of which the author has no knowledge; he is, however, very enthusiastic over the results. The results described in this paper are not picked samples but represent the general run of the work done.

In regard to the third feature, it is well known that most steel, when cast, has a coarsely crystalline or fiery structure, but an examination of the fresh fractures of this steel shows that this is almost wholly absent; in fact, the structure of this steel, as cast, looks much more like that of forged steel than it does like a casting.

Various photomicrographs of a tool manufactured by the Davidson process are presented. From them it appears that the structure consists of a light matrix in which are embedded three other constituents. One is a dark, mottled material resembling troosto-sorbite in ordinary carbon steel and also resembling the dark constituent in a cast high-speed steel of ordinary composition. The second constituent is a light, hard one forming a herringbone design and is plainly a eutectic of some sort. The third constituent consists of a series of separate, small, rounded, hard, white spots similar to the excess carbide found in an ordinary high-speed steel both before and after hardening, provided the sum of the carbon, tungsten and chromium contents are high enough.

The author concludes with the following statement:

"Since the feathery constituent mentioned by Mr. Boylston, and shown in the photomicrographs of the Davidson tool, appears from Mr. Boylston's statement to be rather rare and is abundant in this steel, I am led to think that the surprising quality of these

tools may be due, in some degree, to the presence of this constituent. It seems well to point out here, however, that the metallography of the cutting tools is not sufficiently developed to enable us to say, even from a good photomicrograph, that a certain tool is definitely good or bad. The science will undoubtedly reach a state of development where this will be possible, but for the present the only safe gage of the quality of high-speed steel tools is a test under working conditions, the test to be continued to destruction if possible. Judging from the number of cases in which the cast tools have outstripped all others in such tests, a suggestion not unworthy of consideration is that the structure shown by the Davidson tools is that at which other toolmakers should aim." (*Bulletin of the American Institute of Mining Engineers*, no. 146, Feb. 1919, pp. 353-360, 6 figs., *dA*)

MEASURING INSTRUMENTS

Resilience Factor in Instrument Calibration

The Concept of Resilience with Respect to Indicating Instruments, Frederick J. Schlink, Mem.Am.Soc.M.E. In an earlier paper entitled Variance of Measuring Instruments and Its Relation to Accuracy and Sensitivity (Bureau of Standards Scientific Paper No. 328, 1918), the writer discussed the so-called hysteretic types of errors. The hysteresis loop obtained upon the performance of a proper cyclic calibration gives a representation of the behavior of an instrument as regards the consistency or reproducibility of its calibration. Furthermore, a simple quotient of the areas marked out by the cyclic calibration curve defines a factor which may be called the resiliency of an indicating or controlling instrument.

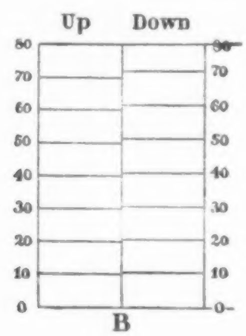


Fig. 8 Calibration of Ordinary Steam-Engine Indicator

(Reproduced from a textbook on the indicator; shows the equivalent, when pencil displacement is plotted against pressure, of a closed hysteresis loop)

There are actual energy losses which occasion the hysteresis in the calibration and the nature of which is discussed, and it appears that the variability of a non-integrating instrument can always be expressed in the form of a lost-work diagram, although in some cases the transformation of the coördinates must be resorted to to permit direct planimetric evaluation of the losses.

In order to give such a hysteresis loop definiteness and value for the purpose in hand, the instruments must be operated a number of times over the cycle under investigation in order to get it into the cyclic state, just as is done in determining the hysteresis characteristics of magnetic specimens and in exact determinations of the stress-strain relations of structural materials. Moreover, between the points of reversal, the change of the independent variable, that is, the quantity which the instrument is intended to measure, must take place slowly and aperiodically and without jarring or vibration, so that the pointer at no time overshoots its reading, since all revertive or vibratory movement of the mechanism tends to displace the corresponding part of the hysteresis loop toward the normal or ideal calibration line to an extent dependent upon the magnitude and number of the precedent excursions. Setting up the cyclic state as defined above, has the effect of obliterating, as it were, the previous operational history of the instrument and of making the hysteresis loop a closed figure of definite area. It is recalled that the hysteresis effect observed in common indicating instruments is in large measure due to journal friction, and that the slack-bearing condition or backlash, so-called, is responsible in a quite definite way for the phenomena noted. It appears that the cyclic state can be readily set up in all indicating instruments except those in which transient phenomena are of importance even at relatively slow rates of change of indication, and second, those in which an uncompensated backlash exists. Even in the latter case, the difficulty in setting up the cyclic state applies only to a fraction of the range of indication or operation, while in the former it has been shown that if the rate of change of the independent variable be constant, cyclic performance is ultimately possible.

It has been already shown experimentally that the normal loop corresponding to cyclic operation of a typical instrument without viscous drift or elastic after-effect, over its full capacity range of operation, is a maximum of all loops obtainable for any two turning points lying between the chosen extreme turning points, and, moreover, completely encloses and circumscribes all such minor loops, a result which involves conclusions of direct value in permitting the utilization of indicating instruments of very ordinary quality for work of relatively exact character, to which they have not hitherto been considered adaptable.

Both the shape and the area of the hysteresis loop come into consideration, in defining distribution of the energy loss in the instrument over the operating range, as well as the amount of such loss.

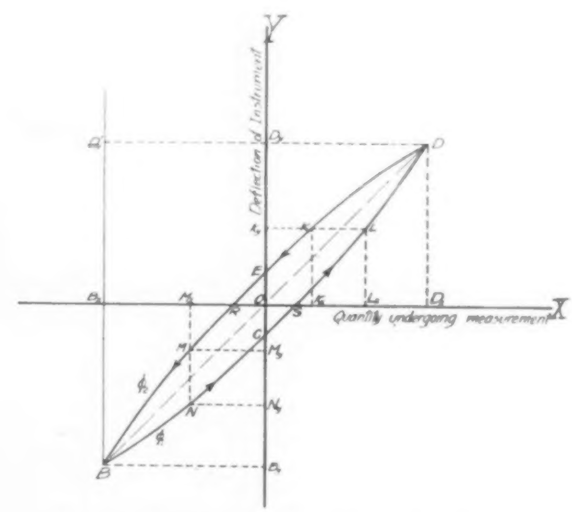


Fig. 9 General Form of Hysteresis Loop of an Instrument Reading in Both Directions From a Central Zero

K_yL_y = range of values of the quantity measured for a given deflection K_y

$_yN$ = range of deflection or indication for the value M_y of the quantity undergoing measurement

Area $BCDE$ = energy dissipated in the instrument during the cycle

Area $BEDD'_y$ $= \int_{By}^{Ry} [\phi(y) - \phi_2(y)]dy$

Area $BCDD'_y$ = efficiency of resilience or *resiliency* of the instrument over the cycle BDB.

The diminution of frictional lag, occasioned by properly applied vibration treatment, is very striking, and it would appear that in cases where the determinate nature of the hysteresis observed under the stated conditions does not suffice to make the instrument usable for a given purpose, in-built mechanical or electrical vibrators analogous to that used in the Cuttriss modification of the Kelvin siphon recorder would be distinctly serviceable. It seems reasonable to suppose that vibration will also reduce that portion of the hysteresis which arises in imperfect elasticity or other molecular causes, including even irreversible time effects, since it has been shown to act with that

tendency in the case of transient and intransient magnetic and electric phenomena.

Experimental data are not available to permit of satisfactory analysis of the energy loss associated with the movement of a liquid meniscus in a tube and in similar circumstances, which is the problem offered by manometers, spirit levels, hydrometers, etc. It is definitely known, however, that a measurable intransient instrumental lag exists in such instruments, and the author ventures the suggestion that the effect may be the one well known in inverse form in the capillary electrometer or possibly the thermodynamic transfer involved in all changes in the configuration of a free liquid surface, as treated in the work of Kelvin. It is undoubtedly true that the irreversibility of a liquid-column instrument must often be taken into practical consideration, and the common assumption that such effects are absent or negligible is by no means a safe one. The case of a dirty liquid surface, such as is sometimes seen in a barometer, is of course simple, and the action easily accounted for on the basis of a granular type of friction. The evidence, however, appears to indicate that this is by no means the sole or even the most potent cause of the difficulties with respect to variability met with in liquid-column instruments.

Quantitative comparison of instrument performance by the use of their resiliences requires equivalence of the range of reading or operation for the instruments compared or determination of the function connecting energy loss with the range of observation. This latter is now known for but a limited class of instrument elements. (Elastic Hysteresis in Steel, F. E. Rowett, Roy. Soc. Proc., vol. 89A, p. 528, 1913.)

Distinction is drawn between the utilization in the performance rating of instruments, of the ordinary methods based upon calibration errors and of the proposed method based upon efficiency in energy restoration; and it is held that the latter affords a generally applicable means for distinguishing between the performances of diverse types, while the former method judges rather between individuals. An instrument having high resilience is capable of being given precise adjustment and of utilizing it to advantage in affording a minimum average departure of readings from the mean. When it is recalled that the mean error at any point of the instrumental scale can be readily reduced as nearly to zero as we may desire, by proper adjustment of the instrument or by remarking the graduations, it will be seen that the calibration error affords but limited information as to the possibilities of the instrument. On the other hand, the variance errors as completely exhibited in the hysteresis loop, are in large measure inherent and cannot be eliminated by any such adjustment, so representing within certain limitations rather the performance of the class to which a given operating principle or mechanism pertains. It is shown that the true criterion for the utility of a given operating element, when ultimate accuracy is the dominant consideration, is the measure of the contribution of that element to the hysteresis loss of the instrument whether that contribution be the effect of frictional resistances or of imperfect elacticity. (Bureau of Standards, Advance publication, *tA*)

METAL-WORKING TOOLS

British Inserted-Tooth and Thread Milling Cutters

British Milling Cutters. Abstract of two articles in recent issues of *The Engineer* (London), the first describing the so-called Francis inserted-tooth milling cutter, as to which very little information was available until quite recently.

This cutter was developed at one of the British National Shell Factories in order to permit the production of howitzers on tools previously used for shell manufacture, the problem being to perform by means of a lathe operations which would have been performed in the usual course of things by means of a planing machine. In this instance it was desired to remove surplus metal in an operation on a howitzer tube by means of two lathes converted into a horizontal milling machine. To do this it was necessary to take the cut not along the length of the barrel but around it, and for this the cutter would have to be something over 2 ft. in length. The Francis cutter was developed to take care of such operations as this. There are two particular points of novelty about it, viz., the manner in which the teeth are arranged on the body and the manner in which they are attached to it. The first point is illustrated diagrammatically in Fig. 10. In the ordinary type of inserted-tooth milling cutter the body is grooved with a number of spirals in the direction indicated at *C*; that is, approximately parallel with the axis of the cutter. Each slot is filled either with a single blade or with a number of individual cutters *B* separated by distance pieces *E*. In the latter case the teeth in one slot are arranged to slightly overlap longitudinally the teeth in the succeeding slot, so that taken as a whole the teeth

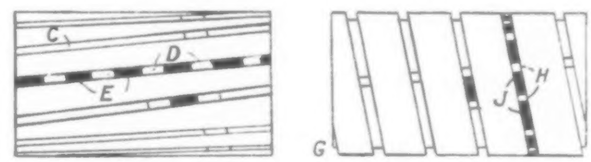


Fig. 10 Methods of Inserting Teeth in Milling Cutters of the Ordinary (Left) and Francis (Right) Types

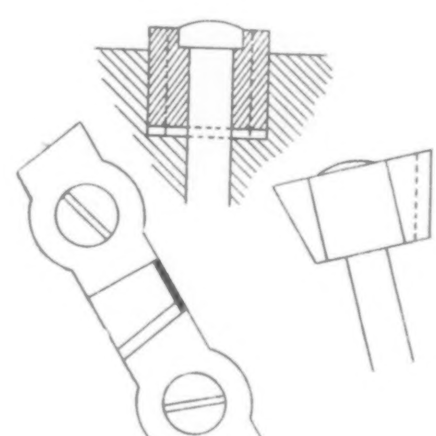


Fig. 11 The Most Recent Type of Francis Cutter

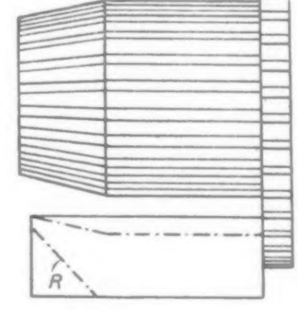


Fig. 12 Method of Forming the Teeth in the Francis Milling Cutter

follow one another round the body in a spiral, approximately at right angles to the axis of the cutters. This is shown in the left-hand view. In the Francis cutter (right-hand view) the grooving forms one continuous spiral around the body of the cutter substantially parallel with that on which the teeth lie in the ordinary cutter. The groove is filled with teeth *H* and distance pieces *J*, the teeth being disposed so as to form rows substantially parallel with the grooves in the ordinary cutter. Therefore the teeth in both cutters occupy the same relative position, with the difference, however, that in the ordinary cutter they are forced by the

pressure of the cut against the edges of the grooves, that is, against the metal of the body, while in the Francis cutter the teeth are pressed against the distance pieces. This difference is of considerable practical importance. In the ordinary cutter the tendency is for the pressure of the cut ultimately to widen the cross-section of the grooves so that the teeth become loose, and the cutter body is rendered useless until the grooves have been reshaped. In the Francis cutter the distance pieces are case-hardened. The pressure of the cut does not tend to deform the cross-section of the groove, and should slackness develop as a result of the cutting pressure it can readily be taken up by simply tightening the wedges or distance pieces. In actual practice, though,

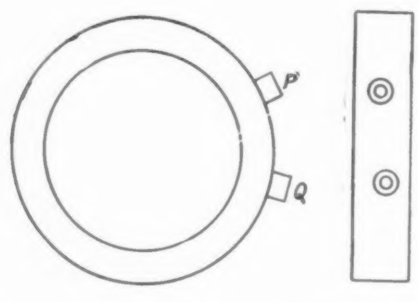


FIG. 13 SPECIAL JIG USED FOR DRILLING HOLES IN FRANCIS CUTTER

it is found that the pressure of the cut renders the teeth not slacker but tighter, so much so that when it is desired to recharge the cutter it is invariably found that the teeth and wedges have settled down so firmly that after the securing screws have been loosened the wedges have to be jarred from their seats before the teeth can be removed.

The most recent form of the cutter is shown in Fig. 11, this form being convenient both from the point of view of operation and from that of toolroom production. The wedges which formerly had rectangular ears are now formed with circular swellings on their faces and are plane surfaced both on the top and bottom. It is found possible to produce them in this form with sufficient accuracy by drop-forging the parts requiring only to be drilled and touched up by grinding before being case-hardened. Furthermore, the substitution of the round swellings for the square ears permits the undercutting of the groove to be dispensed with and the concave recesses can very readily be formed by drilling after the groove has been cut. A special jig shown in Fig. 13 has been developed for this when the holes are being bored. It is in the form of a ring which is clamped round the cutter body by means of set screws and carries two drill guides P and Q, the pitch of which is accurately fixed as the value required to give the desired alignment of the teeth. With the jig fixed in position the first hole is drilled through the guide P, the jig is then rotated until an accurately fitting plug can be passed down the guide Q into the hole already drilled. The second hole is then drilled through the guide P, the plug is removed and the whole operation repeated until the whole surface of the cutter body has been covered.

The method of forming the teeth is illustrated in Fig. 12. The block of high-speed steel, cut roughly to length, is placed in a small vise which holds it at the required angle, and a milling cutter of special form is fed across it to face the base and form the front flank. It will be noticed that the milling cutter is coned so that the tooth is formed with a rake at the cutting end. The angle of this rake is sufficient to bring the front flank of the tooth five or six degrees beyond being radial when the tooth is assembled on the body. Thus the teeth are given a positive front rake. It is usual in ordinary milling cutters, at least such as are used for finishing cuts, to make the front flanks of the teeth radial. A positive front rake is, however, advocated by some as a means of increasing the life of a roughing cutter, and this has been followed in this case. The corner R, Fig. 12, has still to be removed. At present this operation is performed by an additional milling process, but as the surfaces at R, when the teeth are completely assembled on the body, lie in a series of spirals—see Fig. 10—it is proposed to assemble the cutters R by grinding. The relief and sharpening—and subsequent resharpening after use—of the actual cutting edges of the teeth are effected by means of the arrangement illustrated in Fig. 14. In this arrangement the cutter is fed longitudinally over toward the left past a grinding wheel. The pressure of the wheel on the edges of the teeth holds each tooth, as it passes the wheel, down on to a pointed guiding plate up which the under surface of the tooth travels by reason of the longitudinal feed. In this way the cutter is automatically rotated by just the right amount as it moves along. The axis of the cutter is of course set a little below the axis of the wheel, so as to give the requisite relief to the cutting edge.

The article describes in considerable detail many of the applications of the Francis cutter; for example, its use for the machining of 6-in. howitzer breech rings and the machining of stay-

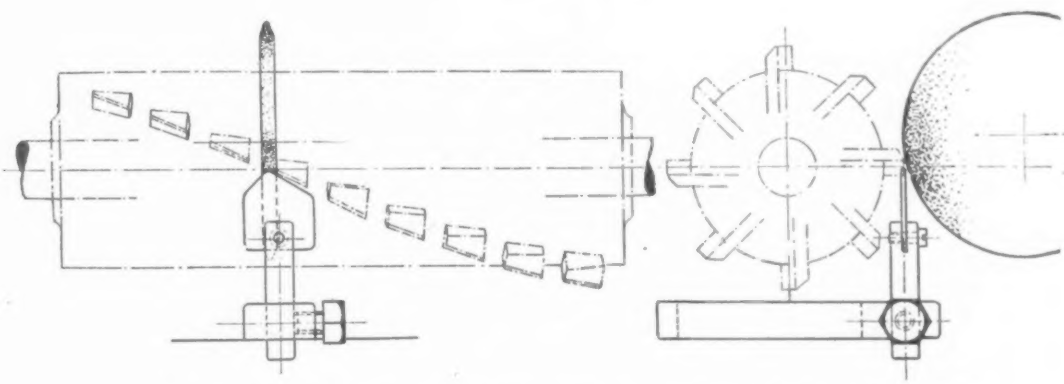


FIG. 14 RELIEVING AND SHARPENING TEETH OF FRANCIS MILLING CUTTER

bolts for naval 10-in. bomb throwers on an adapted lathe. (*The Engineer*, vol. 127, no. 3288, Jan. 3, 1919, pp. 6-8, 18 figs., *d*).

Another British type, in this instance for thread milling, is represented by the "Cycloid" cutter, Fig. 15. It has been found in external thread milling that the ordinary thread-milling hob has a tendency to produce "waves" and "flats" on the work. By "flats" is meant any portion around the circumference of the work at which the diameter of the work is less than elsewhere and the tendency to produce them may be ascribed to the fact that the thread-milling hob has a concave cutting action in relation to the work; in other words, that the cutter tends to get into and below the arc line of the circle it is operating upon.

The Cycloid cutter is claimed to be capable of overcoming this. The cutter head is designed as a hollow cylinder and is attachable to an ordinary chuck plate. The cutter end of the head is milled at intervals to receive a series of independent thread-milling cutters, which are clamped in position in the cutter head by means of slotted studs, fitted with nuts. The independent cutters are backed off, or relieved, and are adjusted internally by means of diametric gages, which enable each cutter to be set truly to any

given diameter within the scope of a given size of head. The cutter, when assembled, has the general appearance of an inserted-tooth die head, but there are the following differences: The inserted teeth are backed off; they are of less width; the thread cutting angles have no thread pitch; the cutter circle exceeds the diameter of the work.

The cutter rotates on the live spindle of the machine. The work, on a work-holding spindle fitted with a leading screw, is brought within the plane of the cutters to the desired extent, and is then moved transversely on the slide toward the cutters until the desired depth of cut is obtained. The work is then rotated until the thread-milling operation is completed.

It will be seen that the cutting teeth of this cutter move in a circle around the work, and therefore describe an arc of a circle which is more or less parallel with the arc of the circle it is desired to produce on the work. Each cutter makes a convex sweeping cut on the work, and at least three cutting teeth, it is stated, are usually actually cutting on and around the work at the same time. A more perfect circle can thus, the designers claim, be produced by their cutter than by one made on the old method. It is further claimed that in the event of an inserted cutter being broken it can be taken out and another substituted at little cost. The independent cutters do not distort in hardening, and can be relied upon to run true, so that "waves" are avoided. They can be quickly removed from the cutter head, and ground on any ordinary type of grinding wheel which is in good condition, and can be replaced by any mechanic of average ability. The cutter head will take a fair range of work of varying diameters, and can be made on the hollow-spindle principle to run in bearings for screwing shafts, etc. (*The Engineer*, vol. 127, no. 3294, Feb. 14, 1919, p. 159, 1 fig.)

POWER-PLANT ENGINEERING

High-Pressure and High-Temperature Steam in Large Power Stations

The Use of High-Pressure and High-Temperature Steam in Large Power Stations. The writer discusses the subject from the point of view of expediency, mainly on the basis of British practice. He says that a good case can be made out for a jump to 600 lb. pressure with the total temperature of 700 to 800 deg. fahr., which will, however, involve a considerable amount of development and experimental work being borne by the enterprise first to adopt such a pressure. On the other hand, it appears that practically all designs of existing apparatus can be so modified as to admit of pressure from 350 to 400 lb. per sq. in. He believes therefore that the pressure of 350 lb. can safely be adopted.

When considering any results of tests on high-pressure or high-temperature steam-generating plant, it is essential that the tests on the boiler side and the tests on the turbine side be studied separately; furthermore, it must be remembered that any results obtained on an extra-high-pressure boiler can be obtained and considering the boiler apart from the economizer, surpassed on a similar and similarly equipped low-pressure boiler. The use of the temperature-entropy diagram is recommended to determine the gain due to increasing the working pressure and temperature ranges of steam.

The writer makes up several schedules showing the comparisons of coal, steam and heat consumptions in various plants operating under various conditions.

Table 1 is a schedule of particular interest in this connection. It was made for a 20,000-kw. machine running at 200 lb. and 350 lb. pressure by gage at various superheats; also at 500 lb. pressure absolute and 268 deg. superheat, at which pressure and superheat the total temperature will be 736.5 deg. fahr., which is about the maximum temperature at present recommended for materials now used in turbine construction. For the purpose of these calculations a turbine ratio efficiency of 80 per cent is assumed at both 200 and 350 lb. pressure, with the steam superheated 150 deg. and a constant vacuum of 28.5 in.

This schedule shows that the cost for coal when generating 175.2 million kw-hr. with a load factor of 100 per cent will be £64,400 at the higher pressure and superheat 250 fahr., and £69,200 at the lower pressure with corresponding superheat. Unfortunately the load factor of 100 per cent is impossible and the conditions under which power stations are operated must be considered before even an approximate estimate of working costs can be arrived at.

In this instance the writer proposes to assume the same standing loss of coal due to no-load consumption for the station design for 200 lb. as in an actual British power station of approximately the same dimensions, which is 1583 lb. per hr. For a 20,000-kw. set the no-load consumption will be approximately 22,000 lb.

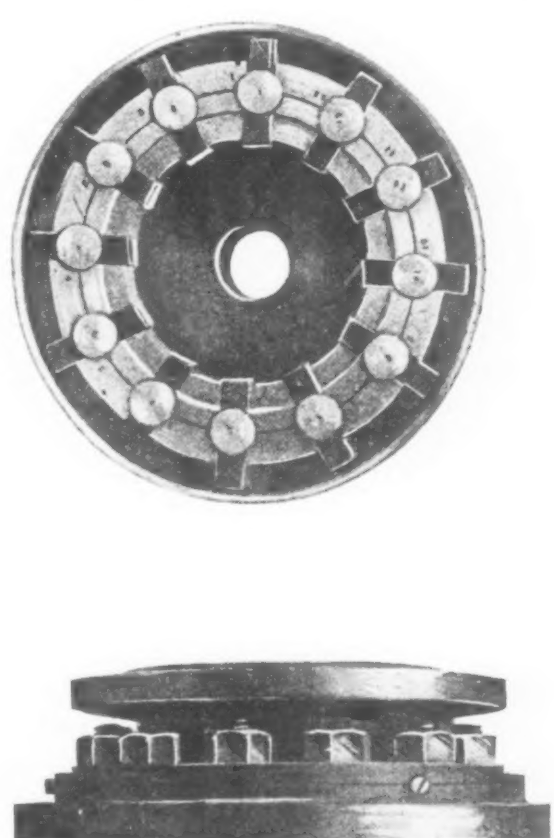


Fig. 15 Cycloid Thread-Milling Cutter

of steam, or 3666 lb. of coal per hr., and these figures plotted in conjunction with the steam consumption shown in Table 1 give the total steam consumption at any load as 22,000 lb. plus 9.54 lb. of steam per kw-hr. for the plant operating at 200 lb. pressure; 22,000 plus 8.6 lb. of steam per kw-hr. and 3729 lb. plus 1.45 lb. of coal per kw-hr. for the plant operating at 350 lb. pressure and 250 deg. superheat.

With regard to the practical difficulties, it is only to be expected that, before pressures of 500 or 600 lb. per sq. in. are adopted, a radical departure will have to be made in present boiler construction. All square boxes and headers will be eliminated, the drums and tubes will be smaller in diameter, and the design of the boiler made more elastic. The type of boiler will no doubt assume the appearance of a flash boiler, with practically no steam or water reserve, and fired by gas on the surface-combustion principle.

For the more moderate pressures, up to 350 lb. per sq. in., the existing type of boiler can be modified and successfully used. At the Carville power station Babcock & Wilcox marine-type boilers are being used at 275 lb. per sq. in. gage pressure, and at the British Thomson-Houston Company's works at Rugby a Babcock & Wilcox boiler is installed and successfully working at 350 lb. per sq. in. Further, Messrs. Babcock & Wilcox state that they have at present two boilers on order for a working pressure of 475 lb. per sq. in. with steam superheated to a final temperature of 700 deg. fahr., and that they are quite prepared

to supply boilers in their ordinary business for such pressure and superheat.

With higher steam pressure the temperature of saturation is raised and, due to this, greater care must be exercised in the quality of the water used for the boiler feed. A feedwater that is perfectly satisfactory at 380 deg. fahr. in a modern tubular boiler might be quite unsuitable for use in a flash boiler. The quantity of air, CO_2, and oxygen will have to be kept down to a minimum, and also the non-soluble salts which are generally in the water discharged from an ordinary lime-soda water softener. A natural development, and one which is already taking place, is to heat the feedwater under atmospheric pressure by means of live or exhaust steam in order to drive off the entrapped and dissolved gases as much as possible. According to a table extracted from Lunge's Technical Chemist's Handbook, it is necessary to raise the temperature of the water to 100 deg. cent. before the quantity of air in the water is appreciably reduced.

The source of water for use in high-pressure plants will have to be carefully traced, and the treatment of the water should be such that a minimum of unsoluble salts remains in it after treatment. The purer the water the greater affinity it has for air, CO_2, and oxygen, and every care should be taken that it is not exposed to the air between the condenser and the boiler. In order to avoid such exposure to the air it is suggested that the feed pump should be an extension of the condensate pump and the condensed water pumped direct into the feed line.

The natural development of the turbine for higher pressures appears to be in a line with the Parsons two-cylinder machine, with a flexible claw-type coupling between the cylinders and a thrust bearing for each cylinder. For very large sets, above 50,000 kw., the cross-compound turbo-generator will no doubt be used, with each side connected to a separate generator. Each set can then be run at its most suitable speed, with resulting high efficiency. This arrangement will no doubt lead to reheating the steam after it leaves the high-pressure turbine and before entering the low-pressure machine. Dr. Ferranti has already done valuable work on this subject, the results of which have unfortunately not been published.

The design of the condensing plant is not likely to be modified because of the use of high-pressure or high-temperature steam, but the fact must not be lost sight of that with steam initially at the same temperature but at different pressures the plant using the high-pressure steam will reject less heat units to the condenser per pound of steam used in the turbine.

The steam pipes to be used in a station where both high pressures and high temperatures are employed will have to be very carefully designed. (*The Journal of The Institution of Electrical Engineers*, vol. 57, no. 278, Jan. 1919, pp. 73-82, *pt.1*).

TABLE 1 TESTS OF A 20,000-KW. TURBINE AT HIGH STEAM PRESSURES AND SUPERHEATS

Absolute Pressure at Turbine Exhaust, 1.5 in. Mercury (91.7 deg. fahr.). Condensate Temperature, 85 deg. fahr.

Steam Pressure at Turbine	215 lb. per sq. in. (abs.)					365 lb. per sq. in. (abs.)						500 lb. per sq.in. (abs)
Superheat of Steam at Turbine, Deg. Fahr.	100	150	200	250	300	50	100	150	200	250	300	268
Total temperature of steam at turbine, deg. fahr	487.9	537.9	587.9	637.9	687.9	486.4	536.4	586.4	636.4	686.4	736.4	736.4
Total heat in steam from 32 deg. fahr., therms per lb	1,265.0	1,293	1,319	1,345.5	1,371	1,249	1,278.5	1,307	1,335	1,363	1,389	1,382.7
Heat drop per lb. of steam, therms	379.1	391	403.4	416.1	429.2	402.4	415.4	428.7	442.2	456	470.2	485
Ratio efficiency of turbo-alternator	76.5 %	77.6 %	78.4 %	78.9 %	79.2 %	75.1 %	76.5 %	77.6 %	78.4 %	78.9 %	79.2 %	79.0 %
Internal efficiency of turbine	80.86%	82 %	82.8 %	83.3 %	83.64%	79.4 %	80.86%	82.0 %	82.8 %	83.34%	83.6 %	83.4 %
Steam consumption of turbine, lb. per kw-hr.	11.77	11.255	10.79	10.402	10.04	11.30	10.746	10.265	9.85	9.491	9.17	8.913
Total steam consumption of turbine, lb. per hr.	235,500	225,100	215,960	208,000	200,800	226,000	214,930	205,300	197,000	189,800	183,400	178,300
Heat rejected to condenser from 32 deg. fahr., therms per lb	950	973	984	998	1,010	929	940	955	969	983	996	975.7
Ratio of circulating water to steam condensed	44	45	46	46.5	47.0	43	44	45	45.5	46	46	45
Circulating water, quantity, gal. per hr.	1,035,000	1,012,500	993,600	967,200	940,000	971,800	946,000	925,200	897,200	874,000	840,000	800,000
Power for circulating pumps, b. hp.	163	160	157	153	149	154	149	146	143	138	133	124
Power for air and condensate extraction pumps b.hp.	89	86	83	80	77	86	82	80	77	74	72	70
Power for boiler feed pumps, b.hp.	104	100	96	92	89	166	157	151	145	140	135	177
Power for induced-draft fans, b.hp.	222	220	220	216	212	218	212	207	203	200	195	186
Power for small auxiliary motors, b.hp.	57	56	55	54	51	61	58	57	55	54	54	56
Total power for auxiliaries, b.hp.	635	622	611	595	578	685	658	641	623	606	589	613
Total power for auxiliaries, kw	530	515	510	495	485	565	540	530	515	500	485	510
Net output to busbars, kw.	19,470	19,485	19,490	19,505	19,515	19,435	19,460	19,470	19,485	19,500	19,515	19,490
Heat in steam from temperature of hotwell, therms per lb	1,212	1,240	1,266	1,293	1,318	1,196	1,226	1,254	1,282	1,310	1,336	1,329.7
Steam consumption per effective kw-hr. lb.	12.096	11.552	11.08	10.666	10.296	11.628	11.044	10.545	10.110	9.735	9.398	9.146
Pounds of steam evaporated and superheated per lb. of coal, lb	6.394	6.25	6.121	5.99	5.88	6.48	6.32	6.18	6.045	5.91	5.8	5.83
Coal consumption per effective kw-hr., lb.	1.891	1.848	1.810	1.78	1.751	1.794	1.747	1.706	1.672	1.645	1.62	1.569
£Cost of coal at 10s. per ton, generating 175.2×10^6 kw.-hr.	74,100	72,400	70,800	69,200	68,500	70,250	68,400	66,750	65,500	64,400	63,400	61,400

IMPROVED METHOD OF FIRING OIL UNDER STEAM BOILERS (*Zeitschrift für Dampfkessel und Maschinenbetrieb*, December 13, 1918). Oil blown into a furnace through a nozzle usually spreads conically, and there is difficulty in intimately mixing the spray with air so as to obtain perfect combustion.

Excess of air is usually admitted, even to the extent of 320 cu. ft. per lb. of oil, instead of the 170 cu. ft. theoretically required.

Good results have been obtained by permitting air to enter through a nozzle discharging to the interior of the conically shaped oil spray. The air should be heated by passing it through tubes embedded in the brickwork of the furnace, and meet the oil close to the orifice of the nozzle. The outer portion of the oil spray is supplied with air through the fire door in the ordinary way. It is possible in this manner to obtain intimate mixture before combustion takes place, and a high temperature of the internal air supply still further increases the efficiency.

It is advisable to have separate fans for the internal and external air supply, although they may be driven from the same motor in order that the air discharge may remain proportionate. The pressure of the latter must, however, be sufficient to overcome

resistance in the preheating pipes. (*Technical Supplement to the Review of the Foreign Press*, vol. 3, no. 4, Feb. 18, 1919, p. 113, no. 4216, *p*)

REFRIGERATION

Vapor Refrigeration Processes and Their Entropy Diagrams

VAPOR REFRIGERATION PROCESSES, Prof. P. Ostertag. A good way to secure a simple and clear comprehension of the cycle in the vapor-compression refrigerating machine is by using the entropy diagram. Heat energy dQ at temperature T may be considered as being a product TdS and may be represented as a strip on a plane surface with temperatures T as ordinates and entropy increments dS as abscissæ.

As long as the carrier of cold is in a liquid state the points representing the state of the matter are all located on the lower limit curve (specific volume of vapor $x = 0$) and the saturated state of the vapor is designated by the upper limit curve ($x = 1$). The curves to the left of the lower limit curve indicate the region of the elastic fluid and those to the right of the upper limit curve the region of the superheated steam, while the points between the two curves indicate the wet vapor. The Carnot cycle may be considered as an ideal process. The fluid carrier of cold (point A in Fig. 16) is superheated to the high pressure p_1 and to the correspondingly high temperature t_1. The high temperature t_2 necessary to produce cold is secured by adiabatic expansion (AB) in cylinder EZ, Fig. 17, whereupon a part of the liquid is gasified. The rest of the liquid in the evaporator V takes up an amount of heat Q_2 from the surrounding medium and thereby produces a cooling effect represented in Fig. 16 by the rectangle BCO_2O_1. Now the cooling material must be compressed to its initial pressure p_1, which is carried out adiabatically in cylinder KZ (CD, Fig. 16). If the end point D in Fig. 16 is still in the region of saturation (wet process), then as the last variation of state

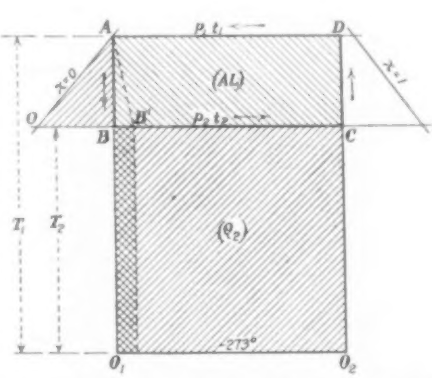


FIG. 16 ENTROPY DIAGRAM, CARNOT CYCLE AND WET PROCESS

DA, the heat Q_1 (rectangle DAO_1O_2) has to be abstracted, which is done in the condenser K.

The closed process gives a cold output K_s and requires an expenditure of work K, of which the heat value AL ($A = 1/428$) is shown as the rectangle $ABCD$. From Fig. 16 it follows that

$$\frac{Q_1}{T_1} = \frac{Q_2}{T_2},\ Q_1 = Q_2 + AL$$

The cold output per hp. is

$$q_s = \frac{Q_2 \times 3600 \times 75}{L} = 632 \frac{T_2}{T_1 - T_2}$$

Hence the output of a plant is the greater the less the temperature difference between the cooling water and the brine.

The first deviation from the described process consists in replacing the expansion cylinder by a simple throttling valve (R in Fig. 17). In the diagram the line AB is replaced by the throttling curve AB'; the output of cold decreases by the rectangle comprised under BB' and the consumption of work increases by OAB.

The second change consists in the introduction of the *dry process*. There the compressor sucks in only vapor which is provided by the introduction of a liquid separator A_1 (Fig. 18) in front of the compressor. This carries the heat absorption in the evaporator up to the upper curve (point C in Fig. 19).

The compression at once brings the vapor sucked in into the state of superheat represented by the adiabatic line CD. Among the advantages of this process it was found that the cylinder contains no liquid which would condense on the walls and hinder the flow of heat from the walls to the vapor; furthermore, the

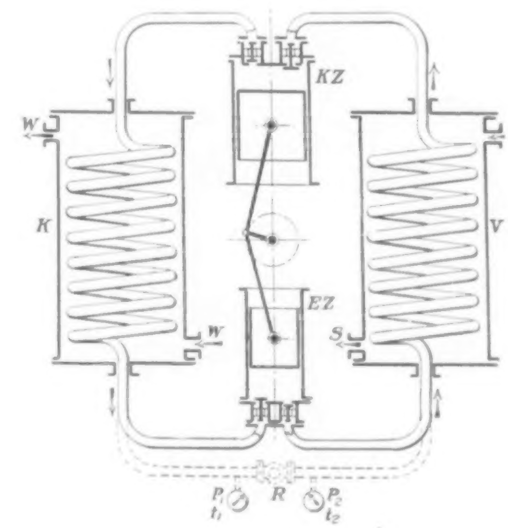


FIG. 17 ELEMENTARY VAPOR REFRIGERATION TYPE MACHINE

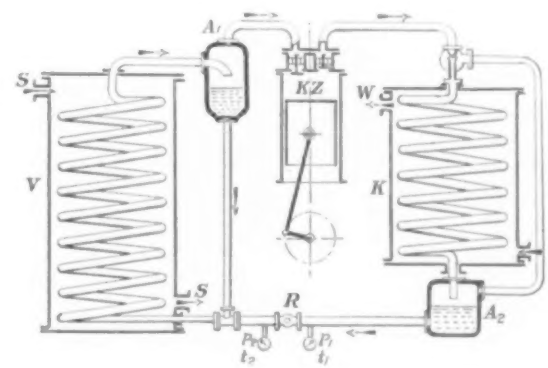


FIG. 18 DIAGRAMMATIC REPRESENTATION OF DRY-PROCESS VAPOR REFRIGERATION TYPE MACHINE

same condensed liquid decreases the efficiency of operation through evaporation from the clearance during expansion, which makes all presence of moisture in the compressor undesirable.

On the other hand, flooding is necessary to enable the flow of heat to occur freely. This is achieved by placing the liquid separator A_1 high and by leading back to the evaporator (Fig. 18) the liquid which has separated.

The compressor KZ forces the hot gas from above into the condenser K. If desired it is possible to produce a nozzle action at the entrance into the coil in order to suck away any gases that may remain in the collector A_2 and drive them once more into the condenser.

If the condenser has been so designed as to have a surface of liberal dimensions and the cooling water W is circulated in countercurrent at a lively rate, it is possible to cool the condensate below the temperature of saturation (from t_1 to t_u). In the diagram Fig. 19 the throttling curve AB shifts to A_uB_u and the gain in undercooling is represented by the rectangle of width BB_u. This action becomes particularly noticeable when carbon dioxide is used as the carrier of cold, since this material has a

very large heat of liquid. Frequently in plants of this type a special liquid cooler is placed behind the condenser as was done for example in the installation exhibited by Escher Wyss & Co. at the National Exposition in Berne in 1914.

For example, let it be assumed that in the evaporator there is a

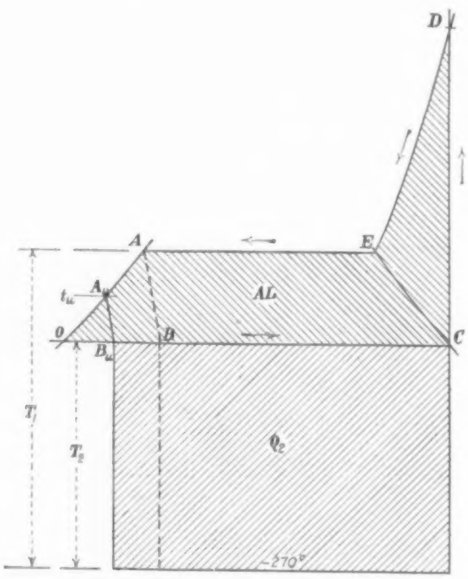


FIG. 19 ENTROPY DIAGRAM, TO ACCOMPANY FIG. 18

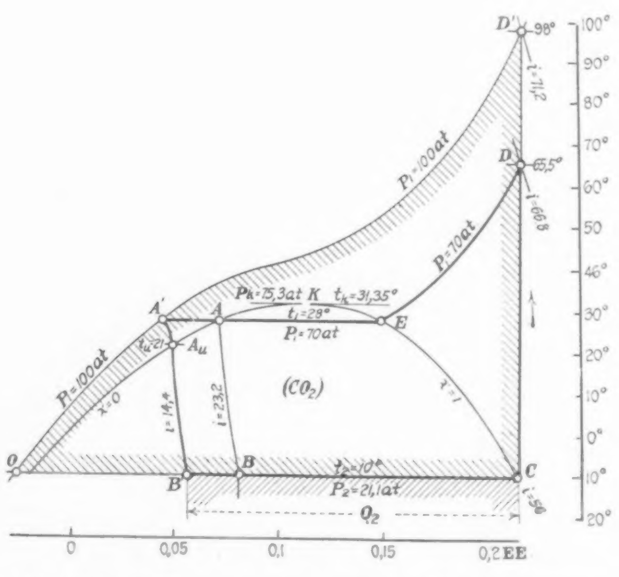


FIG. 20 ENTROPY DIAGRAM FOR CARBON DIOXIDE REFRIGERATING MACHINE

temperature of — 10 deg. cent. and in the condenser one of 28 deg. cent. The compressor then has to compress the vapor from 27.1 atmos. abs. to 70 atmos. abs. (CD in Fig. 20). The work necessary for this purpose may be represented as the difference of heat content between D and C, or $AL = 66.8 - 56 = 10.8$ cal.

The condenser has to get rid of a considerable amount of heat in order to attain the state of saturation (area under EE) and still more heat (rectangle under EA) in order to liquefy the vapor. If no undercooling can take place, the material carries its heat of liquid $i = 23.2$ calories through the throttling valve into the evaporator (AB) where the heat output is $Q_2 = 56 - 23.2 = 32.8$ cal.

This gives per hp. $q_s = 632 \times \dfrac{32.8}{10.8} = 1920$ cal.

The Carnot cycle would have given $q_o = 632 \times \dfrac{263}{38} = 4370$ cal.

Hence, the efficiency as referred to the Carnot cycle is 44 per cent.

The results will be more favorable if we assume that the cooling water is capable of undercooling the liquid carbon dioxide to 21 deg. (AA_u). Then only 14.4 calories will be carried over into the evaporator and

$$Q_2 = 56 - 14.4 = 41.6 \text{ cal.};\ q_s = 632 \times \frac{41.6}{10.8} = 2440 \text{ cal.}$$

The efficiency will now be 56 per cent or 12 per cent higher than before.

In order that the same output of cold may be possible without there being an opportunity for undercooling the gas must be compressed to 100 atmos. (CD') and the consumption of work must be $AL = 15.2$ cal. The cooling occurs then above the

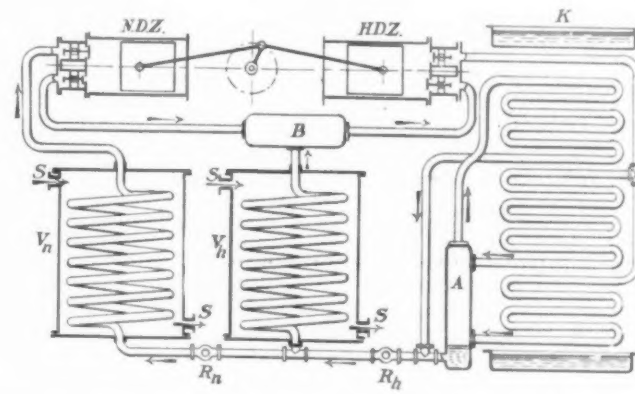


FIG. 21 REFRIGERATION MACHINE WITH INTERMEDIATE EVAPORATOR AND TWO-STAGE COMPRESSION

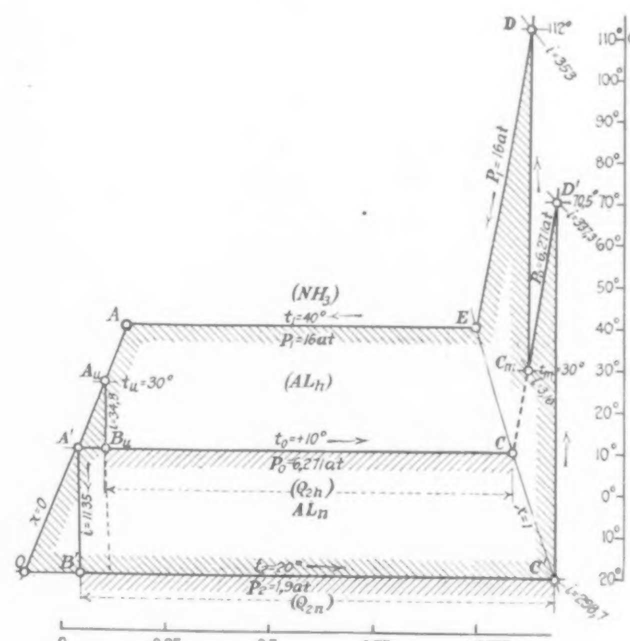


FIG. 22 ENTROPY DIAGRAM, TO ACCOMPANY FIG. 21

critical point K ($D'A'$) and the transition into the elastic or liquid state occurs without a sharply defined vapor formation.

Another process has been proposed by R. Plank. The gas is compressed only to 70 atmos. After the cooling the liquid undergoes an increase of pressure from 70 to 100 atmos. in another pump (AA') so that the same cooling effect is secured. The work of the pump in Fig. 20 is shown as a rectangle under AA', but on the other hand, the work of the compressor is somewhat less as indicated by DD'.

In Fig. 21 is shown a scheme of an *intermediate evaporator with a two-stage compression.* Such a system is useful when cold has to be produced in two places at different temperatures. The colder vapor flows from the evaporator V_n to the low-pressure cylinder (*NDZ*, Fig. 21) and from there to the high-pressure cylinder *HDZ*. On the way it mixes in container *B* with the warmer vapor which has already produced a cooling action within smaller temperature limits in the evaporator V_h. Both kinds of vapor are forced from the high-pressure cylinder *HDZ* into the condenser *K* and thence flow through the regulating valves R_h and R_n into the evaporator. The scheme as shown comprises a spray condenser of the Riedinger type in which the coil is divided into three zones.

The two lower zones produce the cooling and the condensation and the remaining vapor rises from the separator *A* to the uppermost coil where the fresh cold water produces a most powerful cooling effect. The diagram of this process (Fig. 22) applies to the case of ammonia under the assumption that the cooling water is capable of producing undercooling from 40 to 30 deg. (AA_u). Upon throttling (A_uB_u) to the pressure p_o in the evaporator V_h, a part of the liquid produces an output of cold (B_uC) equal to Q_{2h} = 271.8 cal. The other part of the liquid goes through the second valve ($A'B'$, Fig. 22), and produces in the evaporator V_n a cooling effect ($B'C'$) equal to Q_{2n} = 287.35 cal.

During the compression in the low-pressure cylinder *NDZ*, the steam is superheated to 70.5 deg. ($C'D'$) and enters the container *B*, together with the steam from V_h having a temperature of + 10 deg. This produces a combined temperature which

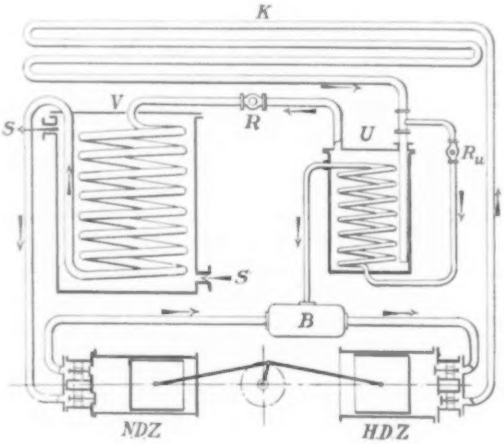


FIG. 23 REFRIGERATION MACHINE OF LARGE SIZE; TWO-STAGE COMPRESSION WITH UNDERCOOLER

may be at first estimated as t_m = 30 deg., which is the temperature making it possible to close the diagram with the line C_mD.

The two work areas of the diagram comprise then

$$AL_h = 353 - 316 = 37 \text{ cal.}$$

and

$$AL_n = 337.3 - 298.7 = 38.6 \text{ cal.}$$

If we assume a desired output of cold of 500,000 cal. so distributed that 200,000 come from V_n and 300,000 from V_h, then the respective weights of the circulating material are

$$G_h = \frac{300{,}000}{271.8} = 1104 \text{ kg}; \; G_n = \frac{200{,}000}{287.35} = 696 \text{ kg}.$$

making altogether 1800 kg. From this it appears that the consumption of energy apart from incidental losses is

$$N_h = \frac{1800 \times 37}{632} = 105.5 \text{ hp.}; \; N_n = \frac{696 \times 38.6}{632} = 42.5 \text{ hp.}$$

or altogether, 148 hp. Hence, the plant delivers an output of cold per hp. of q_2 = 3380 cal.

In the ideal process the two rectangles AL_h and AL_n have to be differentiated, and from them may be developed the equation

$$q_o = 632 \frac{G_h Q_{2h} + G_n Q_{2n}}{(G_n + G_h)\, AL_n + G_n AL_n}$$

$$= 632 \frac{G_h T_0 + G_n T_2}{(G_n + G_h)\,(T_1 - T_0) + G_n\,(T_0 - T_2)}$$

In our example it appears that q_o = 4120 cal. per hp., which in the present process gives an efficiency, apart from incidental losses, of 82 per cent.

In the container there will be a combined temperature of

$$t_m = \frac{(696 \times 70.5) + (1104 \times 10)}{1800} = 33.4 \text{ deg. cent.}$$

Therefore there must occur in the container a cooling amounting to 3.4 deg. in order to arrive at the assumed initial combined temperature. As regards the dimensions of the cylinder, the specific volumes *d* at the points *C'* and C_n give the necessary information. It is found that

For the low-pressure cylinder: v = 0.637 m³ kg.; Total volume = $0.637 \times 696 = 444$ m³/h.

For the high-pressure cylinder: v = 0.24 m³ kg.; Total volume = $0.24 \times 1800 = 432$ m³/h.

Both cylinders are therefore of approximately the same size.

In large plants two-stage compression may be used either to produce lower temperatures or to increase the effect when only warm cooling water is available. The undercooler *U* is built in the manner of an auxiliary evaporator to which a small part of the cooling liquid goes through the throttling valve R_u (Fig. 23), while the main part creates a pressure in the closed boiler *U*. The undercooling is therefore produced by the liquid acting as a carrier of cold. Its effect is independent of the cooling water and is so regulated by the valve R_u that only vapor is permitted to reach the high-pressure cylinder *HDZ*.

The article describes also installations where several places (as, e.g., cellars) at a distance from each other are supplied with cold from the same central plant (Entwicklungsformen des Dampf-Kaelteprozesses, Prof. P. Ostertag, *Schweizerische Bauzeitung*, vol. 73, no. 4, January 25, 1919, pp. 33-35, 9 figs. *t*)

STEAM ENGINEERING

WATER CIRCULATION IN BOILERS, A. D. Williams. Discussion of conditions affecting the operation of boilers from the point of view of water circulation, in particular as applied to water-tube boilers. The discussion is of a rather general nature, the most interesting part of it being that dealing with the influence of steam bubbles on the circulation of water. The writer believes that a modification of the design of the Nielausse boiler having the filled tubes set vertically with the manifold at the top may offer almost unlimited forcing possibilities, greatly exceeding the evaporative capacity of existing boilers. On the other hand, such a design with an internal tube in each water tube would be extremely difficult to clean. In any design to secure increased circulation it is important that the course of the water and of the steam bubbles should be arranged in such a manner that they will not impede each other. Theoretically, there should be no limit to the amount of forcing which a vertical-tube boiler can stand except the heat-absorption capacity of its heating surface. With inclined tubes the boiler can be forced only to the extent of turning a sufficient amount of water into steam to occupy the full area of the hottest tubes at their highest point. Any further forcing with this type of boiler will cause it to destroy itself. (*Power*, vol. 48, no. 8, Feb. 25, 1919, pp. 285-286, *pt*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

MECHANICAL ENGINEERING
THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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Contributions of interest to the profession are solicited. Communications should be addressed to the Editor.

Spring Meeting

THE program for the Spring Meeting, to be held at Detroit, Mich., June 16 to 19, is to include several subjects which are considered by the Committee on Meetings to be of widespread interest to engineers at the present time. It should be remembered that the meeting will be opened on Monday, June 16, instead of on Tuesday as has usually been the custom, in order to provide for a large number who will probably come from a distance and who could most conveniently leave so as to reach Detroit on Monday and be permitted to return to their homes before the end of the week to attend to business matters.

The Business Meeting will be held on Monday afternoon, followed by the report of the Aims and Organization Committee. This Committee is shortly to have a meeting of its members who come from all parts of the country, representing as they do the different Sections of the Society, at which all the essential features of the report to be presented at the Spring Meeting will be prepared. The work of this Committee is regarded as among the most important of the recent activities of the Society and of far-reaching consequence to the membership and profession generally. Every member who can do so should arrange to be at the meeting on Monday afternoon to hear this report and to participate in the discussion. On the days which follow there will be a session devoted to the all-important subject of Engineering Research conducted by the Research Committee of the Society. Another session will take up industrial relations with reference to recent developments and tendencies, with a view to forming a clearer conception of what the relations must be between employer and employee in order to secure industrial peace. One session is to be under the auspices of the Detroit Local Committee and of the Mid-Western Local Sections, with papers contributed by the several Sections. There will further be several miscellaneous sessions of technical interest to the membership generally.

As would be expected, the Detroit Committee already has extensive plans under way to make the visit a pleasant and profitable one to all who attend. There will be a boat excursion on the Lake on Wednesday, extending into the evening, and one other evening will be spent at the playground of Detroit, Belle Isle; while on the third evening will be a lecture of interest to members and guests alike. Detroit, situated as it is, within reach of the great industrial Middle West, with its wonderful industries which every one wants to visit, ought to draw a large attendance. Every one who expects to go is asked to make early reservations of rooms at the headquarters, Hotel Statler.

The Aeronautical Exposition

In another column in this number will be found a brief account of the remarkably fine aeronautical exposition recently held in New York. The thousands of people who visited the exposition must have realized as never before that we are literally at the threshold of a new era in peace-time development, the ultimate outcome of which can scarcely be imagined.

The exhibits were the more striking in that almost all of the recent progress of the art of flying has been made under war conditions, and consequently was kept secret to a very large extent from the public. What we are seeing now revealed is the hitherto largely hidden accomplishment of three or four years of work.

The forerunner of changes and advancement in our conditions of living has very often been some extension of the means for transportation and communication. Even before this number of MECHANICAL ENGINEERING reaches its readers such an extension may occur through the effort at transatlantic flight by airplane or dirigible or both. If successful, this will be comparable in the matter of expediting travel to the memorable voyage of the *Great Western* in 1838 and the completion of the first transcontinental railroad in 1869.

Proposals for Technical Institutions to Obtain Government-Owned Machinery

The period of reconstruction through which we are now passing presents many problems of infinite possibilities and not the least of these is the disposing of over $2,000,000 worth of machine tools purchased by the Government for its war work.

The law provides that these machine tools must be disposed of so that the Government will obtain the greatest possible return. It is estimated that only about one-third can be utilized in existing Government shops and arsenals and to dispose of the remainder at sacrifice prices would unquestionably demoralize the machine-tool industry, as most machine shops are well supplied at the present time.

To guard against this possibility a bill was introduced in the House of Representatives on February 4, 1919, under the terms of which the Secretary of War would be empowered to lend to trade and technical schools and universities such machine tools as would be suited to their use but which are now owned by the United States Government. The bill makes proper provision for the protection of the Government's interest, as it makes each institution responsible for the proper care and for the return of such equipment when demanded. If this bill becomes a law the Government will thus be relieved of the expenses incident to storage, but its passage is chiefly desirable since it will provide the means for the training of many who might otherwise be deprived of such instruction if dependent upon the present facilities of many of our institutions.

Education of Disabled Soldiers and Sailors

As reported in MECHANICAL ENGINEERING last month, extended provision has been made by the Government and the Y. M. C. A. for the continued education of soldiers who remain in France, both by instruction at vocational schools established at camps and by courses at the universities.

The Government has also made provision for the further education of returning soldiers and sailors who have been disabled in

service. The Federal Board for Vocational Education has been charged by the Vocational Rehabilitation Act with the reëducation of disabled, discharged soldiers, sailors and marines. A central office has been established in Washington with 14 district offices in the following cities: Boston, Mass.; New York, N. Y.; Philadelphia, Pa.; Washington, D. C.; Atlanta, Ga.; New Orleans, La.; Cincinnati, Ohio; Chicago, Ill.; St. Louis, Mo.; Minneapolis, Minn.; Denver, Colo.; San Francisco, Cal.; Seattle, Wash.; and Dallas Tex.

Each district office deals with all cases arising in its own district, the procedure being as follows: A representative of the board, called the "Vocational Adviser," makes a survey of the situation in each case, getting information concerning general education, previous occupation, nature of disability, preference as to future occupation, etc. On the basis of this interview a recommendation is made, and if finally approved by the central office, arrangements are made for training, either in existing educational institutions or in industrial plants. It is the policy of the board to give each man a thorough education, not simply a superficial training in some one process, the length of training varying, of course, with different cases. Assistance is given in securing a suitable position in which is served a probationary period under the direct supervision of the board, in order to determine whether or not a man is successfully placed.

Novel Training Work Directed by Local Section Chairman

There are about 150 men in our Army who were totally blinded in the war and about 75 others whose vision has become so defective that they will need practically the same training as those who are totally blind. The work of training is to be carried on at the Red Cross Institute for the Blind at Baltimore, which will give courses in agriculture, business, commerce and industrial work. Mr. L. W. Wallace, Chairman of the Indianapolis Section of the Society, has just gone to Baltimore to become Director of Industrial Training at the Institute.

The work is being carried on at the Institute in a way that offers a most encouraging outlook for the blinded soldiers. It is not proposed to restrict the training to purely vocational work of elementary character, such as usual at institutions for the blind —work such as broom making, basket weaving, etc. Instead, a careful study is being made of the elements ot skilled operations in the industries by the aid of motion pictures and otherwise for the purpose of adapting these operations to the capabilities of blind men and affording them the opportunity to secure important positions commanding good pay. One of the recent subjects to be studied and analyzed is that of core making. The training is conducted at the expense of the Government and the Red Cross.

Classification of Personnel Exhibit

Employers and others interested in personnel work will have an opportunity to examine the methods developed by the Committee on Classification of Personnel in the Army at an exhibit to be shown on the auditorium (third) floor of the Engineering Societies Building, 29 West 39th Street, New York City, April 1 to 12, 1919. The exhibit will consist of a collection of wall charts, forms, photographs and models showing how the Army finds out what men can do best and how it uses that information; how soldiers are trade-tested, and how officers are rated and fitted into place; how the work is checked and supervised, and its results in the war.

The collection is being shown under the auspices of the National Association of Corporation Schools and the United Engineering Society, representing the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. It was on exhibition for several weeks at Washington, where it excited so much interest that in response to many requests the Adjutant General consented to its display in other cities. Two commissioned officers accompany the exhibit to explain its various features.

Regarding the Use of A. S. M. E. Headquarters for Army Training

One of the satisfactions experienced by the officers and office staff of The American Society of Mechanical Engineers during the war came from the allotment of two of the Society's rooms to the staff of District No. 2 of the S. A. T. C. The relations were most pleasant, and, although the reading room usually enjoyed by visiting members was temporarily given up, we found all members who called to be glad that the Society was able to make this contribution.

Recently the Secretary received the following letters of appreciation with regard to the occupation of the rooms:

My dear Mr. Rice:

On behalf of the Committee on Education and Special Training, War Plans Division of the General Staff in Washington, and on behalf of Colonel Barton and all persons connected with these headquarters during the past four or five months, I wish to thank you for the many courtesies and civilities extended to us collectively and individually by The American Society of Mechanical Engineers during the period that we were the guests of the Society in their home on West Thirty-ninth Street.

Cordially yours,
E. S. L. Price,
Colonel Inf., U. S. A.,
District Inspector.

My dear Mr. Rice:

Kindly allow me to add my personal thanks to those expressed to you in Colonel Price's letter of February 27th.

During the months that I was District Inspector, of District No. 2, S. A. T. C., and that we were the guests of The American Society of Mechanical Engineers on the eleventh floor of the Engineering Societies Building, we were so kindly and courteously treated and received so many favors and kindnesses from the Society, and from you personally, I want you to know that I individually appreciate it all.

The American Society of Mechanical Engineers rendered the United States a real service during the war, and your gracious kindness will always be remembered by all the War Department's representatives who were fortunate enough to be your guests.

Fraternally yours,
Frank A. Barton,
Lieut.-Colonel, U. S. Army.

A Step in the Direction of Textile Research

There are frequent evidences that need is felt for a larger amount of research work in connection with the industries of this country. A recent instance is the formation of the Textile Research Company, at 34 Batterymarch Street, Boston, Mass. This is an organization by textile manufacturers for the conduct of research or to have research conducted for them along textile lines. Mr. E. D. Walen, late chief of the Textile Section of the National Bureau of Standards, is the manager. Mr. Walen presented a paper at the last Annual Meeting of the A. S. M. E. on the development of a cotton fabric for use on airplane wings, which material proved to be one of the most important factors in the airplane equipment of the Allied Armies.

The need for textile research has been largely brought about through the necessity for using available raw stock and machinery to manufacture materials which have previously been made from specifically selected raw materials. Such a condition has emphasized the advantages to be gained from a more exact knowledge of the properties of raw stock and the effect upon it of various processes. The substitution of cotton for linen for airplane wings, above alluded to, the substitution of cotton webbing for leather straps and many similar accomplishments have demonstrated the feasibility of applying technical information to the manufacture of textiles.

Screw Thread Commission to be Continued

The very important work of the Screw Thread Commission is to be continued for another year. This was made possible on Friday, February 28, when the U. S. Senate passed the bill extending the life of the Commission until March 21, 1920. The promptness with which this bill was passed can be largely at-

tributed to the very favorable report issued by the Congressional Committee on Coinage, Weights and Measures, which, in reviewing the work of the Commission, found that four of the six months granted under the original act were required to compile data and that the real constructive work of the Commission is still ahead.

The chairman of the Commission, Dr. S. W. Stratton, Director of the Bureau of Standards, states in his report that the Commission has held a total of six meetings and that these were attended by 29 representatives of the Army and Navy and 108 manufacturers, as well as representatives of the British Ministry of Munitions and the French High Commission. Before making a final report, he states, the Commission believes that an international conference will be necessary to provide a basis for arbitrary recommendations. However, tentative reports on standards are now being prepared for: terminology, shape of thread, system of coarse screws, system of fine screws, system of small screws, system of pipe thread, system of hose couplings, system of instrument screws, and system of measurement and test.

The Commission also reports that as a result of its studies it has found:

(1) That there is not a common terminology among the users and manufacturers of screws; (2) that there is considerable deviation in many respects from the recognized standard shape of thread on the screws manufactured in the United States; (3) that there is considerable deviation in many respects in the accepted standard of pitch for screws manufactured in this country; (4) that there is not a standard whereby the accuracy of workmanship may be judged; (5) that there is not a standard method of measuring and testing for accuracy; (6) that there are numerous special screws used which are only slightly different, but just sufficiently different to prevent interchangeability; (7) that there is a desire among manufacturers of the United States for an international standard; (8) that an international standard is an absolute necessity if the present shipping and foreign trade program is to be successful; (9) the above conditions have seriously interfered with the naval and military operations during the war, and for many years have constituted a serious hindrance to commerce.

United Engineering Society

EXTRACTS FROM TREASURER'S ANNUAL REPORT FOR YEAR ENDING DECEMBER 31, 1918

THE Surplus Account on December 31, 1917, showed a balance of $8,116.10. This amount has been increased by the surplus from the operating accounts during the year of $5,417.33, making a total on December 31, 1918, of $13,533.43. Of this amount $8,000 has been transferred to Depreciation and Renewal Fund, leaving a balance in Surplus Account of $5,533.43.

The Gross Operating Expenses for the year 1918 were $66,505.57.

The General Operating Expenses during the year 1917 were $53,791.97, showing an increase for the year 1918 of $12,713.60, partly due to the three additional stories first occupied in October 1917.

The funds available for the Library Board, and spent under their direction during the year, amounted to $28,740.29.

The General Reserve Fund of $10,000 created by the Board of Trustees at a meeting held November 18, 1914, to be available to take care of unforeseen fluctuations of income and outlay, has been preserved intact, there arising no calls on this fund during the year 1918.

The Depreciation and Renewal Fund at the beginning of the year 1918 amounted to $75,037.41. During the year this fund has been increased by the sum of $3,126.37 for interest earned by the investments for this fund during the year and accruals, and by $8,000 added from the surplus at the end of the year, making a total of $86,163.78 on December 31, 1918.

In accordance with the authorization of the Board of Trustees September 26, 1918, the sum of $10,000 was invested in Fourth Liberty Loan Gold Bonds (4¼ per cent).

The following summary shows the amounts of the funds held by U.E.S. as of December 31, 1918:

Depreciation and Renewal Fund Dec. 31, 1917....	$75,037.41
Interest on invested funds during the year 1918....	3,126.37
Transfer for the year 1918....................	8,000.00
Total..................................	$86,163.78
General Reserve Fund..........................	10,000.00
Engineering Foundation Fund..................	303,374.80
Library Endowment Fund.......................	102,559.70

ASSETS AND LIABILITIES, DECEMBER 31, 1918

ASSETS

Real Estate	$1,947,171.16
Investments Engineering Foundation Fund...........	303,321.25
Investments Library Endowment Fund..............	102,297.50
Investments General Fund.........................	85,725.00
Cash	12,869.60
Petty Cash	100.00
Unexpired Insurance	5,958.76
Accrued Interest Receivable......................	2,392.02
Accounts Receivable, General.....................	542.58
Bills Receivable	12,500.00
Total....................................	$2,472,877.87

LIABILITIES

Founders' Equity in Property.....................	$1,947,171.16
Due the General Reserve Fund.....................	10,000.00
Due the Depreciation and Renewal Fund............	86,163.78
Due the Library Endowment Fund...................	102,559.70
Due the Engineering Foundation Fund..............	303,374.80
Due for Notes Payable A.S.M.E....................	12,500.00
Due for Accounts Payable.........................	2,090.24
Due for Library 1918, Unexpended Balance..........	274.26
Due for Library Service Bureau, 1918 Surplus........	800.29
Due for Engineering Council, 1918 Unexpended Balance	2,410.21
Surplus (Dec. 31, 1918)...........................	5,533.43
Total..................................	$2,472,877.87

NEW YORK AERONAUTICAL EXPOSITION

THE second aeronautical exposition to be held in the United States took place in New York City in Madison Square Garden and the 69th Regiment Armory, March 1 to 15, under the auspices of the Manufacturers' Aircraft Association.

The first exposition, it will be remembered, was held in Grand Central Palace, New York City, a short time before the entrance of this country into the war, and was mainly remarkable in showing how far behind the state of the art was the domestic development of aircraft engineering and manufacture. From this point of view the show this year was a distinctly pleasant surprise to those who have not been able to follow the advances made in America during the past two years.

The show impressed one as a distinctly big undertaking. The two immense structures were filled to overflowing with exhibits, each of which was of interest. Judging by the number of manufacturers, the quality of the product and the evident organization of the plants which could produce the many exhibits shown, the aircraft industry has come to stay in the United States. It has passed the experimental stage, and is now on a strictly commercial basis in the sense that it is capable of producing planes for certain definite purposes.

As regards the purposes themselves, the situation is perhaps less attractive. The majority of planes shown, if not all, were military types with very large power plants, apparently of short life and requiring considerable skill for their operation. It must not be forgotten, however, that the show as it stood represented an industry created for military purposes and devoted 100 per cent to war work. Since the signing of the armistice the industry has not had time to reorganize on a peace basis, but the show may well be considered as the first important step taken in this direction.

There were many planes of various types displayed—from the immense Caproni and Curtiss triplanes and Dayton-Wright bombers to the tiny Ballila plane of the Ansaldo Company (Italian manufacture) and the Messenger plane made in this country by the Dayton-Wright Company. None of these planes, however, can be as yet considered as suitable for what might be termed everyday use. It is significant, however, that so great is apparently the prospective field of application of aircraft that even these planes will doubtless soon be employed for various peaceful purposes. In fact, it was announced at the show that a New York steamship company will use a fast plane to deliver final manifests and other papers to ships at sea which had to leave port before these papers were ready.

There is a certain amount of difficulty in describing the show, in that in other expositions, such as automobile shows, it has been customary for manufacturers to exhibit new devices or constructions previously unknown to the trade or the engineering profession. From this point of view the show was disappointing, as there was scarcely anything displayed the existence of which was not already fairly widely known. This, however, is only natural, as practically all the manufacturers who exhibited had been working for the Government, largely to Government specifications.

The exhibits referred to in the following paragraphs may be considered as among those with which engineers outside of the still narrow field of aeronautical engineering have little or no acquaintance. No attempt is made, however, to give an exhaustive enumeration.

Among the planes shown the big Curtiss triplane developed just before the armistice is noteworthy from the fact that it combines a very powerful structure having great load-carrying capacity with a certain flexibility of the wings which should give it a high speed. In this respect the Curtiss plane differs essentially from the other big triplane shown, namely, the Bi-motor Caproni machine. Another machine possessing the wing-flexibility feature to a still greater extent is the Christmas biplane exhibited by the Cantilever Aero Company, which, in addition to having flexible wings, is also strutless. These two features in combination should give it a very high speed, provided it proves possible to make the whole structure strong enough to withstand the various stresses in the air.

The Gallaudet machine embodies the novel idea of locating the propeller neither in front nor in the rear of the plane, but right into the fuselage so that the propeller hub and the base of the blades are entirely concealed in the streamline cover of the fuselage body, only the acting tips of the blades projecting. It is claimed that such a structure not only materially reduces the head resistance caused by the propeller, but also creates a different distribution of air pressures that is of advantage in obtaining the maximum effect.

As regards power plants, the show did not bring out anything which was not fairly well known before. Several Liberty engines were on the floor, as well as an aero-marine motor, two Hispano-Suiza engines—one of 160 hp. and the other of 300 hp.—a Packard motor, and several Hall-Scott engines. While none of these engines exhibited any mechanical features not well known in the art, they gave an impression of careful workmanship and average good design.

The B. F. Sturtevant Company exhibited an engine with a centrifugal blower attached for purposes of supercompression. Unfortunately, however, the representatives of the company were unwilling to give any information as to its efficiency or the mechanical details of operation of the supercompressor.

In the field of accessories there were numerous interesting exhibits showing the work done by American manufacturers during the war. The Delco Company had on view the ignition system developed for the Liberty engine, and side by side with it the Splitdorf Company exhibited the Dixie magneto developed for multi-cylinder aero engines of the Liberty type.

The Zenith Carburetor Company showed the enormous carburetors built for the big 12-cylinder Liberty engine, while other companies exhibited the various recording and indicating instruments used in military flying.

Of the Government developments, the Navy had probably the most interesting exhibit; comprising both planes and their armament, including the Lewis gun. A dirigible balloon, a stationary balloon and an exhibit of fabrics in their manufacture revealed the part taken by aerostatics in our military preparedness. On the whole, however, the visitor at the show carried away an impression that while American aeronautics was probably not behind that of England and France at the present moment, it was certainly far behind at least that of the first-named of these countries in lighter-than-air engineering developments.

Several meetings of engineering societies and other bodies were held during the show, the most interesting of which was that of the Aeronautical Society of America, at which Capt. W. R. Schroeder, of the Technical Service, Aircraft Section, War Department, gave a brief talk on high-altitude flying.

Captain Schroeder told of his flights to determine the ceilings of the various types of machines, in the course of which he made what is probably the world's record for altitude, namely, an actual ceiling of about 29,000 ft. This was possible only by using oxygen both for the engine and flier in the last few thousand feet.

A highly significant feature of the last attempt in which the record altitude was reached lay in the following fact: Captain Schroeder rose in a westerly direction, so governing his flight as to come down in a volplane as near as possible to the place from which he rose, which was McCook Field, Dayton, Ohio. He went up for a period of 85 min. and did not give up until all of his gasoline was exhausted. It took him 20 min. to come down in a volplane with the motor dead from the altitude which he reached, and the significant point is that he landed nearly 200 miles east of Dayton, which shows he either encountered extremely powerful winds at the high altitude, or that in some way his flight was affected by some other factor not yet determined—possibly the rotation of the earth. In any case this confirms the statement previously made by Lord Montague de Beaulieu to the effect that in long-distance and high-altitude flights it is very important to take into consideration the winds prevailing at the altitude where the flight is made.

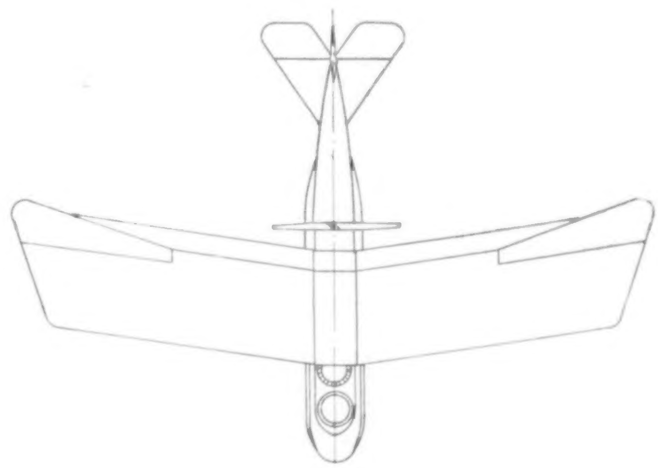

Diagram of Gallaudet Aeroplane

The general impression made by the show is that the American aeronautical industry has come to stay. Apparently it has not yet developed an actual commercial aeroplane, which could not be expected, however, since up to a few months ago it has been working exclusively for our military establishment; but such products as have been shown in the way of planes, engines, and accessories represent a high grade of workmanship and an earnest effort at producing careful designs.

Washington Announces Abandonment of Neville Island

The War Department has officially abandoned the $50,000,000 Neville Island project. A recent announcement of the Department states that the buildings erected there are to be torn down and the island restored to the original owners, but denies the report that the plant is to become the principal ordnance storage depot for the Eastern United States. It will, however, be used temporarily for storage purposes. The Neville Island plant was one of the largest undertakings of this kind during the war. It was intended chiefly for the production of heavy artillery, as no guns of less than 14 in. were to have been built there. Congress appropriated $40,000,000 for the plant and a total appropriation of $140,000,000 had been asked for.

ENGINEERING COUNCIL

Extracts from Annual Report

ENGINEERING COUNCIL has completed its second year. Notable in the year's history are its service to the Government in connection with the German war, the creation of the Engineering Societies Employment Bureau, the establishment of a Washington office, the appointment of a committee on Licensing of Engineers, and the admission of an additional member society. Through visits made by the Secretary mutually helpful relationships with engineering societies in twenty-five or more localities were established.

Engineering Council held six regular meetings beginning with the Annual Meeting, February 21, 1918, and one special meeting on November 21, all in Engineering Societies Building, New York. There was no change in the officers as elected at the beginning of the year: J. Parke Channing, Chairman, Harold W. Buck, First Vice-Chairman, George F. Swain, 2nd Vice-Chairman, Alfred D. Flinn, Secretary. For the year's expenses the sum of $16,000 was provided, and there remained unexpended January 1, $2400. Particulars regarding the activities of the Council's various committees follow.

Executive Committee. Eight meetings were held. The principal business of most of these meetings was the preliminary study of matters to be brought before Engineering Council so as to economize time at Council meetings.

January 6, 1919, an urgent meeting was called to determine what action Engineering Council could take concerning the sudden dismissal, by the Public Service Commission for the first District of New York, of approximately 350 engineers and assistants engaged on subway construction.

January 28 a meeting was held to instruct Council's Washington representative as to his course of action before committees of Congress on matters demanding immediate attention, especially propositions relating to a National Department of Public Works.

Rules Committee. This committee prepared and submitted for adoption at the February meeting, 1918, "Rules for Guidance of Business" and "Rules for Admission of Additional Societies to Membership in Engineering Council." The latter rules were subsequently duly approved by United Engineering Society and the four Founder Societies. A tentative list of societies eligible for membership was prepared and sent to all representatives. From this list six societies were selected for immediate consideration and three ultimately elected, subject to approval by United Engineering Society and the Founder Societies. These approvals were all received by December 1918.

Public Affairs Committee. This committee made preliminary investigations which led to the appointment of a Patents Committee and a Committee on Licensing of Engineers. It presented a resolution to the December meeting of Council, requesting favorable attention of Congress to land reclamation on a large scale as a "reconstruction" measure under thorough engineering supervision. This resolution was adopted by Council and later followed up by the Washington representative. The committee also reported upon the allocation of labor and equipment for production of war materials, an "Institute for History of Science" as a branch of the Patent Office, engineering experiment stations at Land Grant Colleges, assistance to members of faculties of colleges of pure and applied science engaged on war work by relieving them of certain routine duties; no activity was undertaken by Council in any of these matters.

American Engineering Service devoted its energies and those of its small staff almost exclusively to aiding governmental departments in procuring technical men for war service. With the assistance of the four Founder Societies and other engineering societies, classified records of many thousands of engineers were assembled and from these, in response chiefly to more than two hundred requisitions from thirty principal and subordinate governmental departments, names of approximately four thousand engineers were supplied, all carefully selected. Many interviews between Army and Navy officers and candidates were arranged and other services rendered. Besides, a number of engineers were assisted in finding engagements in civilian work and several offices were aided in obtaining engineers. This committee was disbanded at the end of November on account of the armistice and succeeded by Engineering Societies Employment Bureau.

War Committee of Technical Societies. During its latter months the committee had 22 members representing 11 societies. Financial support was provided by Engineering Council. The Naval Consulting Board provided offices in New York, and for the last few months, also in Washington, together with frank for mail and other assistance. This committee was closely allied with the Naval Consulting Board, and, beginning in the summer of 1918, also with the Inventions Section of the Army General Staff: the latter provided the services of Capt. Scott as secretary. On account of the armistice, this committee ceased to exist December 31. During the year this committee aided the Army and Navy in examining 135,000 inventions and suggestions for war devices. To stimulate intelligent solution of war problems, the committee with the Naval Consulting Board issued two pamphlets, the first entitled "The Enemy Submarine" and the second "Problems of Airplane Improvement." Before the bulletins were issued 0.4 per cent only of suggestions received had any value; afterward, 4.7 per cent. One of the most important services rendered was to demonstrate to the War and Navy Departments how the civilian engineers of the country could be mobilized for the aid of the Government in war, and to establish direct communication for this purpose between the departments named and the engineering societies.

Fuel Conservation Committee. This committee has collaborated with the Bureau of Mines and the Fuel Administration, one of its members being Advisory Engineer to the latter, and its Secretary, Chief Mechanical Engineer to the former. This committee also cooperated with committees of various engineering societies, working along similar lines in many parts of the country. Its work will be continued.

Patents Committee. Appointed so that Engineering Council might have a share in endeavors to improve patent-law practice and the organization of the Patent Office. This committee interlocked with a similar committee of National Research Council and accepted the able report of the latter. This report, recently made public, proposes the following changes in the patent system:

1 Establishment of a single Court of Patent Appeals
2 Separation of Patent Office from Department of Interior
3 Increase in force and salaries of Patent Office
4 Modification of that section of the law granting compensation for infringement of patents.

Water Conservation Committee. Was created to deal with questions concerning the utilization and control of water for various purposes in all parts of the country. It has defined its general policies and is prepared to furnish broad information on large problems, particularly to committees of Congress, to State Legislatures, or to governmental departments. The committee proposes to deal with those facts of engineering which are beyond reasonable controversy.

Engineering Societies Employment Bureau. Following the termination of hostilities, Engineering Council at its special meeting November 21, established an Employment Bureau with the secretaries of the Founder Societies as a Board of Directors. The Bureau took over the staff and equipment of American Engineering Service at the end of November. From the beginning of its work to February 15, it has received applications for positions from 1375 engineers in all branches of the profession. For a total of 200 applicants employment has been found. The services of the Bureau are not restricted to members of the engineering societies represented in Engineering Council, but nonmembers are expected to present letters of introduction from a member. Extensive efforts have been made to inform employers of engineers of the Bureau's resources for serving them. No charge is made for services.

Reconstruction Committee. At the November meeting of Council, in order to deal with several matters falling under the head of "reconstruction" and especially to work out the details of the organization and personnel of the proposed National Service Committee, the Reconstruction Committee was appointed. At meetings held November 29 and December 16, 1918, it selected the personnel of the National Service Committee and determined sufficient elements in its organization to permit that committee to begin work before the end of the year. It was understood that the chairman should be the executive head of the National Service Committee with reasonable independence in action for the effective performance of his duties, and that the other members of the committee would be expected to serve principally in the capacity of an advisory board to the chairman. January 28, the Reconstruction Committee held a joint meeting with members of the Public Affairs and National Service Committees to discuss the establishment of a National Department of Public Works.

National Service Committee. At the November meeting of Council, representative Philip N. Moore presented a communication entitled "Representation of Engineers at National Capital." From this proposal grew the National Service Committee with a permanent representative and office in Washington, which was established through the agency of the Reconstruction Committee. The office is Room 502, McLachlen Bldg., 10th and G Streets, Washington, D. C. The committee has taken up a number of subjects with committees of Congress and the departments. Most important among these have been (1) Land Reclamation, following resolution adopted by Council November 21 (Tyrnes Bill S. 13651, proposing an appropriation of $100,000,000 for reclamation of arid, swamp and stump lands); (2) National Public Works Department in connection with Kenyon Bill, S. 5397, and hearings before Committee on Education and Labor to which this bill was referred, and the Committee on Public Buildings and Grounds which was investigating certain work of the Army Construction Division.

License Committee. There is active interest in several states in proposed legislation relating to the licensing of engineers, and a number of inquiries from engineering societies have been referred to this committee. The License Committee is endeavoring to coordinate and direct these activities.

Americanization Committee. Is prepared to coöperate with the Division of Americanization in the Department of Interior and with the National Americanization Committee. Since engineers have more or less direct contact with large bodies of foreign-born employees, it is expected that they will render substantial help in this important work. An instructive report has been written by the committee summarizing the present status of Americanization activities.

Publicity Committee. Is a committee of volunteers to help the Secretary in some of the publicity work, principally in preparing and distributing material for publication in technical journals and daily newspapers after authorization by Council. Besides this New York committee, there are twenty-six correspondents in engineering centers scattered over the country to aid in the transmission of information between Engineering Council's office and local societies of engineers.

American Academy of Engineers. Organizers of the proposed Academy sought the support of Engineering Council in securing a charter from the Federal Government. After several conferences and mature deliberations, Engineering Council declined to support the bill before the House of Representatives.

Classification and Compensation of Engineers in Railroad and Government Employment. A communication prepared by Engineering Council addressed to the Railroad Wage Commission was presented by the Secretary in person to a meeting of that Commission in Washington, February 25, 1918. This matter was pursued from time to time, and with that of the compensation of engineers in Government employment is now in the hands of the Public Affairs Committee.

Reconstruction. Under date of November 15, a letter was sent to President Wilson regarding the appointment of engineers on the proposed Federal Reconstruction Commission. To this letter the President replied briefly under date of November 20, that existing instrumentalities were being utilized. Letters to the governors of all states, urging the inclusion of engineers in any reconstruction commissions which might be appointed, were sent out in February 1919.

Field of Activity of Engineering Council was outlined at the November meeting by carefully prepared preambles and resolutions which have been generally announced to engineering societies.

Information to Federal and State Authorities. At its November meeting, Engineering Council expressed its attitude in the following resolution: "That Engineering Council should be prepared to furnish to Federal and State authorities information regarding engineering and allied facts and opinions which are beyond the field of controversy, and shall take such steps as are consistent with the standing of the societies it represents to inform such Federal and State authorities of its willingness so to act."

Smith-Howard Bill for the establishment of engineering and industrial research stations at educational institutions in all the states was discussed at length. While favoring research when properly carried on, Engineering Council refrained from expressing opinion on the proposed legislation in the form in which it was brought to its attention. Council's Washington representative was directed to attend a meeting January 6, of delegates from organizations interested in redrafting the Smith-Howard Bill; a report of this conference was submitted. The parties interested are still widely at variance and there is nothing further for Council to do at present.

Curricula of Engineering Schools. The subject of changes in curricula of engineering schools was discussed in a general way at more than one meeting. It was brought formally to the attention of Council by resolutions adopted by the War Committee of Technical Societies at its final meeting, suggesting that as a measure of future military preparedness engineer students in the large universities and colleges should receive instruction in the art of war. A committee was appointed December 19 to study this matter. This committee has reported.

Committee of Engineering Council Considering Engineers' License Laws

Engineering Council has appointed a committee on Licensing of Engineers, of which Theodore L. Condron of Chicago is chairman and the other members, 12 in number, are representative of different sections of the country. This bids fair to become one of the most important of the Council's committees in view of the active interest which engineers are taking in various parts of the country in projects for state legislation to regulate the practice of engineering.

Engineers' license laws are already in force in Florida, Louisiana and Illinois, and bills for this purpose have been introduced or proposed in California, Colorado, Nevada, Washington, Iowa, Michigan, Ohio and Indiana. The license law in Florida requires the registration and licensing of all professional engineers practicing in the state, whereas the law in Illinois is limited to the registering and licensing of structural engineers only.

The Louisiana law is "to regulate the practice of civil engineering and surveying; to create a State Board of Engineering Examiners, and regulate the fees and emoluments thereof, to prevent the practice of the said callings or professions by unauthorized persons."

The great changes in conditions which engineers with all other classes of the community face as a result of the war make it desirable that the question of the licensing of engineers should be investigated broadly and impartially by a committee representative of various sections of the country and of different branches of the profession.

Engineering Council, therefore, has divided the country into districts and the different members of its committee, each assigned to a district, are undertaking to gather information regarding the laws in force or proposed and the bearing which they may be expected to have on the welfare of both the engineer and the public. Among the questions now being investigated are the following:

1 Should state laws be enacted requiring definite qualifications for the practice of specific branches of engineering? If so, what branches of engineering work should be included?

2 Should such laws provide for the examination of candidates and formal license to practice, by a state board of duly qualified engineers?

3 Can the dangers be obviated that such legislation would operate to confine engineering work within state boundaries and that it would ultimately be used to raise state revenue by a special tax on engineers?

4 If the legislation above outlined is found to be inadvisable, are other laws or methods possible by which those employing engineers in specific branches of work may be more effectually aided in ascertaining their competence?

In this connection attention should be called to the thorough investigation of the question of a state license law for engineers made four years ago by an expert commission in Pennsylvania. This commission of five eminent engineers was appointed by the governor under authority of an act of the legislature. The commission held public hearings in different parts of the state—and collected a large amount of testimony from engineers representing all branches of the profession. While the commission at the outset apparently was inclined to favor the general proposition of state regulation, its final reports opposed any legislation for the control of the work of engineers engaged in private industry and recommended only examinations for engineers engaged in various branches of public work.

Other Engineering Council Activities

An invitation has been extended to various engineering societies by the Engineering Council to attend a conference in Chicago, April 23 to 25, to discuss the advisability of a National Department of Public Works. There appears to be promise of the passage of a bill by the next Congress for the establishment of such a department if the different societies interested will unanimously agree on and support such a measure.

A new committee about to be appointed by the Council relates to the Classifications and Compensation of Engineers, having as its object the securing of better conditions for employment of engineers, including their classification into grades and a statement of what it is considered should be the relative salaries of the different grades. It is proposed to consider:

1 Engineers engaged in civil, mechanical, electrical and railway engineering, etc.

2 Engineers in Government (national) employ.

3 Engineers in municipal employ.

Still another activity which has recently developed relates to International Affiliation of Engineers, a committee for which has been appointed with Charles F. Loweth as chairman. The primary object is to secure closer coöperation between the engineers and engineering societies in this country and those of Canada.

ENGINEERING RESEARCH

A Department Conducted by the Research Committee of the A. S. M. E.

IN discussing the relation of the Mechanical Engineer to his work in conducting and assisting research, the subject naturally divides itself into two parts: The relation of the individual engineer and the relation of the collective engineer, that is, the Society to which the engineer belongs.

The relation of the individual engineer is one of action and one of encouragement. At present there is, and in fact at all times there has been, a great need for those who would devote themselves to the determination of the unknown, for pioneers to go into the regions of science and lay hold of some of its domain for the use of their fellows. That need is great today since the small chance for a large financial reward and the necessity for close attention to details has taken many men who have started life as investigators out into the more productive fields of commercial life or science after a few close years of research work.

The value of the investigator is quite evident to many manufacturers, and men who have shown ability in their work on large general problems have, on account of greater financial returns, given up this work to the small special problems of commercial plants. It is in this commercial work that the individual engineer can be of great assistance in endeavoring to carry his problems of research to a general conclusion, rather than stopping when a particular or the partial commercial result of his investigations has been attained. Where possible, he should endeavor to influence those under whom he is working to see the necessity of making the investigation general and then giving the result to the world.

Of course many investigations are undertaken for commercial reasons, and the results of such investigations are not to be made public until the commercial purpose for which they were started has been protected. This is undoubtedly the reasonable point of view, although a broader plan would be to open up to the world the results of all research; but this is not to be expected under present conditions. According to the daily press a convention of dental societies agreed to make all special processes or inventions resulting from research the property of the profession at large, giving to all a free use of these results. This broad and altruistic view is to be commended and desired, but in ordinary business it is feared that little support would be given by commercial organizations if there was not some possible gain for them in view.

The individual engineer should realize the importance of research since the physical data which he uses every day have been the result of the researches of others, and for that reason he should endeavor to emulate the action of such, in not being satisfied to use rule-of-thumb methods in new problems, but when data are lacking, he should proceed by research to ascertain the necessary information. He should, where possible, endeavor to encourage others in this field of work. One of the great needs at present is for men with the training, enthusiasm and disinterestedness of investigators and a proper attitude of the individual engineer to encourage young men to enter this field.

Turning now to the interest of the engineers in collective units, I feel that one function of an engineering society is to aid those engaged in research by the six methods which have been undertaken in the present program of the Research Committee of The American Society of Mechanical Engineers, and in addition to these six, the Society should give financial aid to those engaged in general work.

To aid the investigator the Committee is planning to bring together information regarding the researches in various parts of the country, informing the investigators and the engineers of the country about methods and subjects of research, giving information which will bring together those who are interested in the same problems for conference and coöperation, and preventing unnecessary duplication of work. The spirit of coöperation is an important one to foster and by coöperative endeavor great work can be done.

To encourage research the Society should organize committees to superintend actual work. In regard to subjects of general interest, and where present data seem to be in conflict, these committees could investigate the problems further for the purpose of harmonizing the data or by proving which of them are correct. In many cases this work may have to be financed by the Society, while in other cases small grants may be all that are necessary. By its clearing-house methods for research information the Society will discover those requiring assistance, and by a small aid in the time of need, certain researches may be carried to a conclusion, and without such aid they would remain incomplete.

As a duty to the profession the Society should collect and publish the results when such results are not published. It should endeavor to have reports made in a regular way, and even though the results of research have not been published in a limited way, it is advisable to abstract these for publication in our Journal for the benefit of the whole profession.

To help those who have research problems to solve but who have no equipment or other facilities, the Society, through its Research Committee, can aid in bringing together the man with the problem and the man with facilities for research. There is much equipment which is idle for the lack of suitable problems on which work is to be done. It is hoped that this clearing-house method will aid in utilizing some of the equipment.

To those about to undertake research a survey of the present conditions of the field to be covered is necessary, and a study should be made of the literature of this field of endeavor to discover this condition. Bibliographies are necessary, and in many cases persons are situated at such a distance from large libraries that this work could not be done by them. The Society can come to the aid of such persons in preparing for them bibliographies founded on careful searches in the large library of the United Engineering Society. In this way the whole Society can aid. Of course it is realized that this should only be done for those who are working on a general problem and also for a research which is to be given to the profession at its conclusion. Where the research is of a commercial nature, it would be manifestly unjust and improper to give such aid.

To recapitulate, I feel that the activities of the individual engineer should be devoted to carrying on research to such a degree that results would give a general relation rather than the solution of particular problems, that he should endeavor where possible to have these results made public, that he should encourage others in the field of research, and should endeavor to lead those with the proper preparation of spirit to enter such fields. The engineer in a collective sense, represented by the Society, should aid research by financial support of those needing it, by the preparation of bibliographies, by the publication of research problems and of information regarding research equipment for the purpose of bringing it to the knowledge of those who have not the equipment for a problem at hand, by publishing news relating to research in progress, and by publishing research results.

ARTHUR M. GREENE, JR., *Chairman.*

Reports Upon Research

A—RESEARCH RESULTS

Electricity 1-19 Lightning Protection. Circular No. 1 of Engineering Experiment Station, Purdue University, Lafayette, Ind. A collection of facts relative to lightning protection.

Hydraulics 1-19 Flow of Water Through $1\frac{1}{2}$-in. Pipes and Valves, Frederick W. Greve, Jr., Purdue University,

Lafayette, Ind. From Bulletin No. 1, Engineering Experiment Station.

CONCLUSIONS. The loss of head can be represented by equation $h = MQ^n$ for valves and pipes with the exception of check valves at low velocities. In the above formula h = loss of head in feet and Q = cubic feet flowing per second. The values of M and n are given in the Table 1.

TABLE 1 VALUES FOR USE IN LOSS-OF-HEAD FORMULA

Description	M	n
1½-in. pipe per 100 ft	831.0	1.817
1½-in. check valve for Q above 0.043 c.f.s	1276.3	1.944
1½-in. gate valve:		
0.2 in. rise from seat	10067.2	1.946
0.45 in. rise from seat	1854.2	1.946
0.65 in. rise from seat	818.4	1.901
1.00 in. rise from seat	476.3	1.865
Wide open	363.5	1.843
1½-in. globe valve:		
One turn open	5257.4	1.947
1.5 turns open	1703.7	1.881
2.0 turns open	1379.7	1.940
3.0 turns open	1041.9	1.922
5.5 turns open (wide)	953.7	1.915

Fig. 1 shows arrangement of apparatus used in the experiments and Fig. 2 a logarithmic diagram of loss of head and quantity.

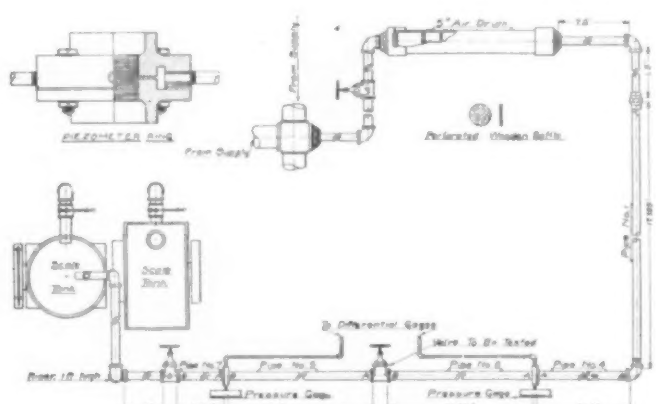

FIG. 1 APPARATUS USED IN LOSS-OF-HEAD EXPERIMENTS

The bibliography given by Mr. Greve is as follows:

1 Donnelly, J. A. . . . Flow of Water Through Check Valves. *Power*, vol. 32, p. 510.
2 Folwell, A. P. . . . Notes on Lost Heads in Water Systems. *Eng. News*, vol. 47, p. 303.
3 Kuichling, E. . . . Loss of Head Resulting from Passage of Water Through a 24-in. Stop Valve. *Trans. A. S. C. E.*, vol. 26, p. 439.
4 Magruder, W. T. . . . The Flow of Water Through Valves. *Eng. Rec.*, vol. 40, pp. 78-79.
5 Pillmore, F. . . . Influence of Valves on the Flow of Water. *Power*, vol. 29, p. 603.
6 Weisbach, J. . . . Tests on Flow of Water Through Valves. Coxe's Translation of "Mechanics."

B—RESEARCH IN PROGRESS

Air 1-19 The Flow of Air Through Orifices. Ohio State University, Columbus, Ohio. Prof. W. T. Magruder.

Automotive Vehicles and Equipment 1-19 Investigation of Oil Constituents in the Crankcases of Automobile Engines After Long Usage. Armour Institute of Technology, Chicago, Ill. Prof. G. F. Gebhardt.

Electrochemistry 1-19 Fixation of Atmospheric Nitrogen by High-tension Currents. Engineering Experiment Station, Purdue University, Lafayette, Ind. Address Director C. H. Benjamin.

Electric Power 1-19 The Efficiency of Electric Ranges. Engineering Experiment Station, Purdue University, Lafayette, Ind. Director C. H. Benjamin.

Fuel Utilization 1-19 The Process Underlying Carburetion. Ohio State University, Columbus, Ohio. Prof. W. T. Magruder.

Fuel Utilization 2-19 Standardization of Gasoline Carburetors. Engineering Experiment Station, Purdue University, Lafayette, Ind. Director C. H. Benjamin.

Heat 2-19 Heat Transmission Through Various Building Materials, Thickness ½ in. to 4 in. Armour Institute of Technology, Chicago, Ill. Prof. G. F. Gebhardt.

Hydraulics 1-19 Friction—Coefficients of Pipe Friction and Constants of Orifices for Pipe Sizes from Two to Four Inches. Armour Institute of Technology, Chicago, Ill. Prof. G. F. Gebhardt.

Internal-Combustion Motors 1-19 Test of 14-in. by 18-in. Single-Acting Tandem Buckeye Engine with Natural Gas Under Varying Conditions. Ohio State University, Columbus, Ohio. Prof. W. T. Magruder.

Lubrication 2-19 A Research on Lubricating Oils. Committee on Lubricating Oils, Bureau of Standards, Washington, D. C.

The program of the Committee is made out under the following heads: 1, General Purpose; 2, General Statement; 3, Some Specific Problems; 4, Engines and Engine Tests Methods; 5, Theory of Lubrication; 6, Routine Tests; 7, Special Laboratory Examinations; 8, Oils for Investigation; 9, Effect of Adulteration; 10, Regeneration of Used Oils.

Metal Manufactures, Miscellaneous 1-19 The Strength of a Fillet Experimentally Determined. Ohio State University, Columbus, Ohio. Prof. W. T. Magruder.

Properties of Engineering Materials 1-19 Alloy-Steels at Varying Temperatures from — 100 to 1500 Deg. Fehr.; Tensile Strength Yield Point, Elongation and Reduction of Area. Armour Institute of Technology, Chicago, Ill. Prof. G. F. Gebhardt.

Road Materials and Equipment 1-19 A Survey of Road Materials of Indiana. Engineering Experiment Station, Purdue University, Lafayette, Ind. Director C. H. Benjamin.

Railroad Rolling Stock and Accessories 1-19 (1) Testing of Street-Railway Car-Axle Boxes, 4½ in. by 8 in. on Their Own Axles. (2) Test of Freight-Car Boxes 5½ in. by 10 in. on Their Own Axles. Ohio State University, Columbus, Ohio. Prof. W. T. Magruder.

Railroad Rolling Stock and Accessories 2-19 Force of Impact of Flat Wheels on Rails. Engineering Experiment Station, Purdue University, Lafayette, Ind. Director C. H. Benjamin.

Railroad Track and Signals 1-19 The Breaking of Steel Rails at Low Temperatures. Engineering Experiment Station, Purdue University, Lafayette, Ind. Director C. H. Benjamin.

Steam Power 1-19 Influence of Back Pressure on the Performance of Small High-Speed Steam Engines. Armour Institute of Technology, Chicago, Ill. Prof. G. F. Gebhardt.

Transmission 1-19 Determination of Belt Slips and Creeps. Belt 4 in. Wide. Armour Institute of Technology, Chicago, Ill. Prof. G. F. Gebhardt.

Transmission 2-19 Bearings—Coefficient of Friction of Annular Ball Bearings Subjected to Combined End and Radial Thrust. Armour Institute of Technology, Chicago, Ill. Prof. G. F. Gebhardt.

Transmission 3-19 Tests with Multiple-Bearing Testing Machine with Speeds at 400 R.P.M. and Under Loads of 15,000 Lb. for 4-in. Shifts. Ohio State University, Columbus, Ohio. Prof. W. T. Magruder.

C—RESEARCH PROBLEMS

During the past month the Research Committee of The American Society of Mechanical Engineers has received word from a number of laboratories that they would gladly help in the work of the Committee if they knew of problems which are worth while. They are willing to work, they have good equipment, but they do not know just how to aid. It is hoped that those who have research problems of a general nature will send in their problems to the Committee, so that these may be published in MECHANICAL ENGINEERING, and those prepared to undertake work can communicate with those having problems.

D—Research Equipment

Apparatus 1-19 Screw Threads—Testing Device for Pitch. Communication B514, Gage Section, Bureau of Standards, Washington, D. C. February 10, 1919.

The Gage Section of the Bureau of Standards has installed in its laboratory devices for measuring the pitch of straight and tapered screw-thread gages. The communication describes the construction of the apparatus, giving a list of the parts required. The general scheme of the apparatus is to advance the gage one pitch by means of a micrometer screw, and to determine whether or not the gage has been advanced exactly one pitch by the movement of an image from a lens at the end of a multiplying indicating bar, the other end of which fits into the threads of the gage. The image is reflected by two prisms to a ground glass in front of the apparatus, and when this image is brought to the same point as that occupied before movement, the gage has been advanced one pitch. The construction of the apparatus is seen from Figs. 3 and 4.

Apparatus 2-19 Screw Threads—Apparatus for Measuring Profiles of Screw Threads. Communication B510, Bureau of Standards, Washington, D. C. December 9, 1919.

The Bureau of Standards has built and installed in the Gage Laboratory apparatus for examining the profiles of screw-thread gages. The principle of the apparatus is to cast a shadow from the profile of the gage through a lens to a mirror placed about 10 ft. above the gage, and to reflect this shadow back to a point near the projecting apparatus. The magnified profile can then be studied and measured. This communication describes the apparatus necessary for the complete installation, and indicates what may be bought in the open market.

Apparatus 3-19 Length Measurements. Communication B508. Gage Section, Bureau of Standards, Washington, D. C. November 12, 1918.

The Gage Section of the Bureau of Standards has prepared a communication on the Precision of Length Measurements. The communication discusses:

A Total Length of Line Standards

B Calibration of Intervals

C Length of End Standards

D Notes on Micrometer Microscopes.

The communication then gives the history of length standards in a brief form, tracing the yard, the toise, the U. S. Standards and the metric standards. The communication refers to Circular No. 2 of the Bureau of Standards, and reprint No. 256 of the Bureau Bulletins for the method of comparison with fundamental standards, and also to the Hansen Calibration of Intervals as given in *Trav. et Mem. du Bur. Int. des Poids et Mesures*, 5-1886. For length of end standards it refers to article by Fischer in *Bulletin of Philosophical Society of Washington*, vol. 13, p. 241. For the calibration of micrometer microscopes it refers to the Bureau of Standards, vol. 10, p. 375, Reprint No. 215.

Purdue University 1-19 Farm-tractor and motor-truck testing plant. Plant for the standardization performance of tractors in a similar way to standardization of locomotive and automobile performance by the same laboratory. Purdue University, Lafayette, Ind. Director C. H. Benjamin. (See Mechanical Engineering, March 1919, p. 295.)

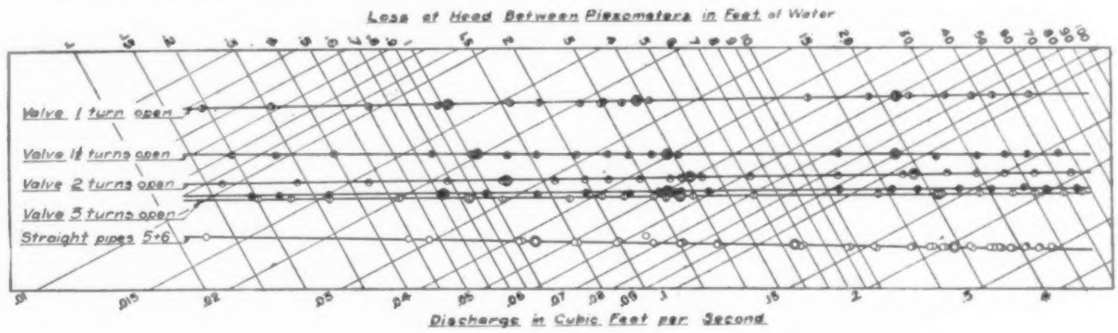

Fig. 2 Logarithmic Diagram of Loss of Head and Discharge

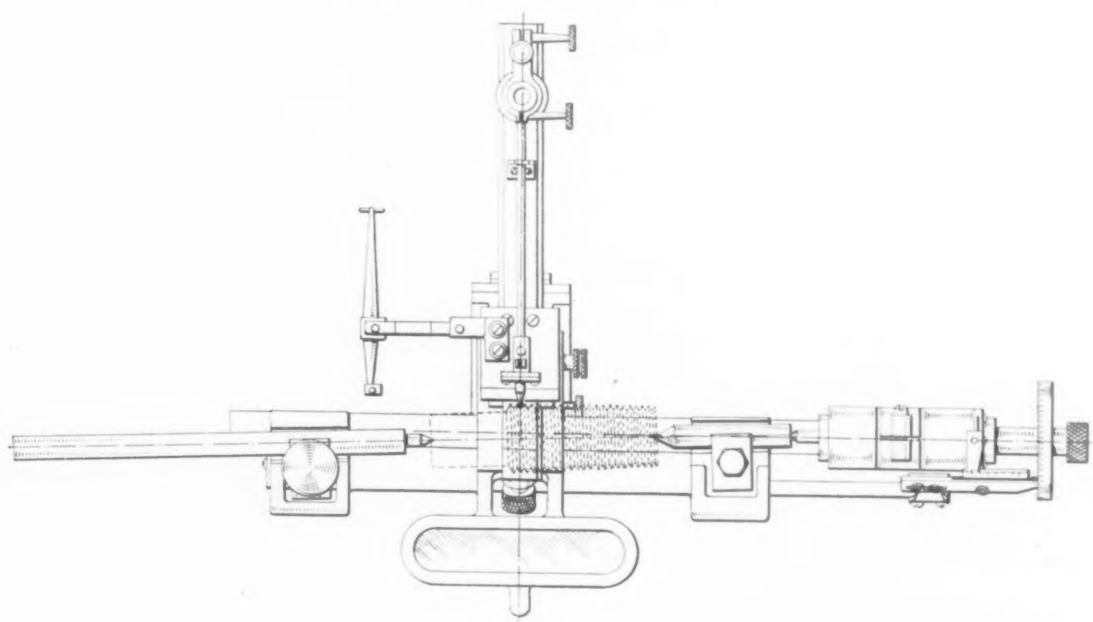

Fig. 3 Plan of Bureau of Standards Apparatus for Testing Pitch of Screw-Thread Gages

Ohio State University 1-19 Belt-testing machine in process of design. Pulleys to 60 in. in diameter and speeds to 10,000 ft. per min.

E—Research Personal Notes

General 1-19 Coöperative Research.

The Experiment Station of the University of Illinois is undertaking a study of hot-air furnaces and hot-air heating systems using these furnaces. The unknown problems of this system of heating are numerous. Many of the present data are based on experiments made years ago, and much practice and many methods of installation are based on trade practice and not on

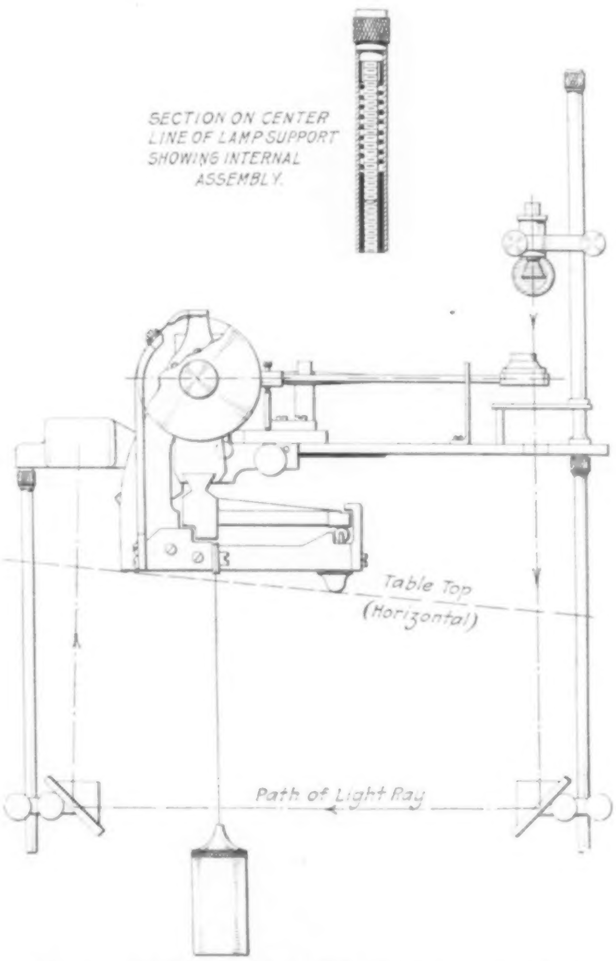

Fig. 4 End Elevation of Apparatus Shown in Fig. 3

scientific data. Such problems as heat losses, velocities, temperature changes, combustion, and multiplicity of risers from one heater are being studied by constructing within the laboratory a model of a house of several floors. In this way the results from actual installations are expected. This work is being done by the Experiment Station, using a grant of funds from an Association comprised of hot-air-furnace manufacturers.

This problem is unique in that it will not only solve many disputed and unknown questions relating to an important system of heating dwellings, but it indicates what may be done by coöperation.

It is one of the hopes of the Research Committee that those who are interested in obtaining definite information relating to problems in their field of activity will combine and make a joint investigation. When the individual companies have not the necessary equipment, personnel and capital for such work, they may, by coöperative effort, arrange with some one having the equipment to carry on the work, the united industries bearing the expense. By this united effort the work may be carried on in a disinterested way, and the results be removed from any suspicion of commercial influence or bias.

TABLE 2 DIAMETER MODIFICATION OF UNITED STATES OR BRITISH STANDARD WHITWORTH THREADS FOR INTERCHANGEABILITY

Pitch		Change in effective diameter for interchangeability, in.	Difference in full diameter required for assembly, in.	
Threads per inch	Inches	Minus on bolts or plus on nuts	U. S. nut B. S. W. bolt	B. S. W. nut U. S. bolt
20	0.0500	0.0024	0.0029	0.0019
18	0.0556	0.0027	0.0032	0.0022
16	0.0625	0.0031	0.0037	0.0025
14	0.0714	0.0035	0.0042	0.0028
12	0.0833	0.0041	0.0048	0.0034
11	0.0909	0.0045	0.0053	0.0035
10	0.1000	0.0049	0.0059	0.0039
9	0.1111	0.0054	0.0065	0.0043
8	0.1250	0.0061	0.0073	0.0049
7	0.1429	0.0070	0.0083	0.0057
6	0.1667	0.0082	0.0098	0.0066
5	0.2000	0.0098	0.0116	0.0080
4.5	0.2222	0.0109	0.0129	0.0089
4	0.2500	0.0122	0.0145	0.0099

If the Research Committee of The American Society of Engineers can bring about a combination of any interests for coöperative research, it will be very glad to act as the intermediary for this purpose.

General 2-19 Research in Engineering Laboratories.

During the past month the Research Committee has communicated with a large number of the engineering laboratories of our educational institutions, and most of the engineering institutions have reported that war work has so interfered with their regular schedule that little or nothing is being done. However, they expect that after next summer work will again become normal and research investigations will be carried on.

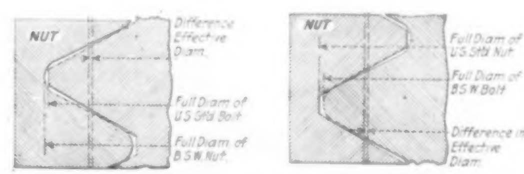

Fig. 5 Interchangeability of U. S. Standard and Whitworth Threads

Apparatus 1-19 Screw Threads—Interchangeability of U. S. Standard and British Standard Whitworth Threads. Bureau of Standards, Gage Section, Sept. 21, 1919. Communication B512.

The Bureau of Standards has issued a table showing that by a slight modification of the diameter of the U. S. or of the Whitworth thread or by a change in both, interchangeability can be secured without changing the form of either. Contact occurs near the crest of the Whitworth thread form or near the root of the U. S. form as shown in Fig. 5. The stress developed in the thread would be the same in both types. The required modification is given in Table 2.

Despite the failure of Congress to pass the Urgency Deficiency Bill, the United States Employment Service will continue to carry on the work of finding jobs for the men who have served their country in its hour of need. While the Service has been cut down 80 per cent, the representatives of the Bureau are still retained in the demobilization camps, and through the coöperation of individuals not connected with the Government, it is believed that many of the offices which it has been announced would be closed, will be kept open. Instead of two offices in New York State, there are indications that the number will reach at least twelve, and the Service has also arranged to continue a total of fifty-six offices throughout the country. John B. Densmore, Director-General of the Employment Service, urges that business, labor, welfare and all other interests in every community in which a federal employment office has been abandoned, take over the office and its work, in order to help meet the emergency.

NEWS OF THE ENGINEERING SOCIETIES

Reports of Annual Meetings of Mining and Electrical Engineers and Electric Railway Association —The Aims of an Engineering Society, etc.

Taylor Society to Locate in Engineering Societies' Building

The Taylor Society, which is perpetuating the doctrines of the late Frederick W. Taylor, Past-President Am.Soc.M.E., hopes soon to secure headquarters in the Engineering Societies' Building. Meanwhile the society is being temporarily accommodated in the rooms of our Society.

Rochester Engineering Society

Members of the Rochester Engineering Society, at its monthly meeting in its rooms, No. 131 to No. 135 Sibley Building, March 14, were addressed by LeGrand Brown, who has been in San Francisco for several years practicing as a consulting engineer, on "California's Development of Natural Resources."

Mr. Brown has been intimately connected with electric railway, power, irrigation and water-supply projects, and has also been brought into constant touch with the economic and engineering development of the Pacific Coast.

He described at length the development of California's electric transportation and natural resources. The Los Angeles aqueduct was shown on the screen and explained, as well as the proposed Hetch Hetchy water-supply project for San Francisco.

Mr. Brown is a charter member and past-president of the Rochester Engineering Society. Before he left Rochester he was connected with the street railway, the building of the Hemlock lake conduit by the city, and earlier electric suburban lines.

Material-Handling Machinery Association Formed

The organization has been completed of an association of manufacturers of machinery for handling materials. The suggestion for the organization was made by the Department of Commerce and the U. S. Shipping Board to facilitate the study of freight-handling methods at railroad and ocean terminals. By mobilizing the experience and ability of all manufacturers of handling devices into a single organization, the Government will not only be able to reach this industry in an effective way when it needs coöperation, but the industry itself can more effectively attack the large and difficult problems presented at terminals and ports.

Other lines of activity are to be taken up, however, in relation to the material-handling problems of the various industries. The president of the association is Calvin Tomkins, formerly Commissioner of Docks, New York City. Headquarters will be at 35 West 39th Street, New York, and the active conduct of the association's work will be in the hands of Mr. Zenas W. Carter, the secretary and manager.

American Welding Society to be Organized

The representatives of over 90 societies, institutions and corporations who during the war greatly developed the art of welding, will meet on March 28, 1919, at the Engineering Societies Building, 29 West 39th Street, New York, with a view of forming The American Welding Society. This Society will merge the Welding Committee of the Emergency Fleet Corporation and the National Welding Council, both of which were created during war times by the Council of National Defense.

The discussions, researches, lectures and conferences, as well as the interchange of views with foreign countries which were carried on during the war, aroused in this country a great interest in the use of electric welding and it is expected that the advance in welding thus made will be continued and extended to the entire field of joining metals. The American Welding Society proposes to bring together, in the manner usual for scientific societies, persons from all branches of the industry who may be interested in any of the welding processes, whether it be forge welding, electrical resistance welding, gas welding or thermal welding.

The society will also create and assist in maintaining a bureau of welding, which will be a separate organization designed to take advantage of the principle of coöperation in research and standardization.

As part of its routine the society plans to conduct a research of the methods of welding and to determine, if possible, the conditions under which the best welds may be secured. This involves investigations of the best current to use with various sizes of electrode and different types of work, and a determination of the proper method of procedure in making up both gas and electric-arc welds, coupled with an adequate system of inspecting the work as it progresses. In arc and gas welding the proper angle of bevel and the space to be allowed between plates must be selected and an investigation made of "electrode" wire and of "welding wire."

In gas, spot, or arc welding, methods of assembling large structures to eliminate initial or locked-up stresses due to contraction on cooling, are also to be investigated.

The benefits of standardization are also well recognized by the new society, for they intend to carry on this important work in a way to meet the approval of the American Engineering Standards Committee.

The Aims of an Engineering Society

At the annual meeting of the Engineers' Society of North-Western Pennsylvania, held at Erie, in January, the newly elected president, Mr. Armin Schotte, C.E., outlined what he believed should be the aims of the society and its part in public affairs. He said:

During the pioneer days, and up to near the close of the last century, engineers organized themselves into societies, which became national in scope. The purpose of these societies was to enlarge the sum total of technical knowledge by the interchange of information among themselves. Such work was of the utmost importance at that time, and was a material factor in adding to the store of available data.

During the last twenty years, however, conditions have changed, and in many cases successful steps have been taken to remedy them. What has proved antiquated and practically useless in the case of the national societies would be still more so in smaller local organizations such as ours. So, since we can hope, as a body, to add but little to the sum total of new engineering knowledge, and if we tried, would probably be wasting time which might be put to a better purpose, why undertake it?

The question naturally arises, What are the aims which justify us in maintaining and fostering our society? Without concerted effort in any way, but rather sporadically, new methods have been developed in the conduct of local engineering associations, and I am happy to say that we have, unconsciously perhaps, generally pursued a policy in harmony with them, to which I believe this society owes a large part of its successful growth.

The ultra-serious consideration of any technical subject has either very little or no place in this new policy. The programs are made up and the subjects treated in a manner to interest not merely specialists, but all classes of technically trained men; and in a large number of cases even laymen. The meetings thus assume an attractiveness which will assemble a maximum number of engineers of various lines, and also laymen, thus aiding to establish proper and pleasant relations among the engineers themselves, and to bring the profession before the public in an effective manner. By continuing this policy we shall soon be able to extend our work and help ourselves and every other engineer to conserve and maintain all of the rights and privileges, both mental and legal, to which the individual and the profession at large are justly entitled; to render to the public such service as we are

qualified to perform; to create the proper appreciation of the function of the engineer generally, be he employee or maintaining an office of his own, and to compel a recognition for ourselves as a necessary factor in the civic and political growth of our community and the nation.

The retiring president, Mr. R. C. Stevens, who was unable to attend the meeting, sent a communication in which he referred to The American Society of Mechanical Engineers as follows:

Another very interesting sign of the times is the increased interest in the human element of engineering. Witness the December meeting of the A. S. M. E., when they held an all-day session on Engineering of Man Power. We have long had papers and discussions on wage systems; but now we have increased interest in welfare, safety and the personal relations of employer and employee. Success in engineering is not alone the mastery of mechanisms and securing output from machines, but also, and more important, the organization and training of men and the guiding of industry to augment the usefulness and happiness of mankind.

American Electric Railway Association

THE meeting of the American Electric Railway Association held in the Engineering Societies Building on March 14 was well attended by electric executives from all over the United States and Canada. The most important and valuable discussion during the convention centered around the report of the Association's Committee on Readjustment. The chairman of this committee, Mr. P. H. Gadsden, president of the Charleston Consolidated Railway & Light Co., submitted a preliminary report embracing the fundamentals of a plan for readjusting the relations between the communities and the electric-railway companies.

The committee reported that the present state of the industry was largely the result of a fixed rate of fare made with little consideration of the adjustment of price to meet cost. It was therefore necessary, if the railways are to survive and continue service, that some system of flexible fares, to increase and decrease as the cost of furnishing the service increases or decreases, be established.

Following the report of the committee there was a discussion of the so-called "service at cost" franchises such as are now in effect in Cleveland, Cincinnati, and Montreal. In these cities the fares are automatically regulated, the company receiving a stipulated return upon its money and the city specifying the service which the company shall furnish for the public.

A. Merritt Taylor, a former manager of the Division of Passenger Transportation for the United States Shipping Board and president of the Philadelphia and Westchester Traction Company, also spoke on Modern Regulatory Plans and Theories.

In the afternoon Francis H. Sisson, vice-president of the Guaranty Trust Company of New York, read a paper on Electric Railways and the Investor; and Hon. Charles E. Elmquist and Hon. William D. B. Ainey spoke on Electric Railways and Regulatory Commissions.

In the evening a dinner was held at the Waldorf-Astoria at which Hon. Francis Burton Harrison, Governor-General of the Philippines; Hon. Lindley M. Garrison, Receiver of the Brooklyn Rapid Transit Company; and B. A. Hegeman, Jr., spoke. John H. Pardee, president of the association, presided.

American Institute of Electrical Engineers

THE Seventh Annual Midwinter Convention of the American Institute of Electrical Engineers was held at New York on February 19 to 21. The opening session was a joint meeting with the American Institute of Mining Engineers, at which matters pertaining to the Engineering Council were considered. Mr. Leighton, representative of the Council at Washington, outlined the plans of the organization, which include a movement toward creation of a department of public works, and a federal engineering department under which all engineering activities of the Government shall be correlated and presided over by a member of the engineering profession.

C. A. Adams, president of the A. I. E. E., gave a brief account of the work of the welding committee, after which the technical papers for the session were presented.

On Wednesday evening Dr. J. A. Brashear delivered a lecture on The New Astronomy to an audience which completely filled the auditorium. The lecture was accompanied by numerous lantern slides showing disturbances on the surface of the sun. These slides had never been shown before. The lecture was followed by an exhibition of moving pictures illustrating the operation of the Burroughs adding machine and the telephone receiver and transmitter.

The technical session on Thursday morning was devoted to a discussion of the various phases of standardization in engineering work. Dr. C. P. Steinmetz presented in abstract his paper on General Equations of the Electric Circuit, and H. S. Osborne discussed the subject of Wave-Shape Standards.

Thursday afternoon was set apart for technical excursions. Inspection trips were made to the Brooklyn Navy Yard and the Bell System Laboratories of the Western Electric Company. Members and guests were transported from the Engineering Societies Building in busses to the foot of 23rd Street, where the Navy Department supplied large sea-going tugs to carry the party to the Navy Yard. The party spent an interesting afternoon inspecting the power plant, shops, dry docks, and various other features of the yard.

The Western Electric Company provided cabs for those who visited their plant. Members and their guests also had the leadership of a guide as they went through the Bell System Laboratories.

The final session was held on Friday and was exclusively devoted to technical papers. Of these the most valuable and interesting was on Radio Telephony, by E. B. Craft and E. H. Colpitts, both of the Western Electric Co. The paper described the development of the art of radio telephony to the accomplishment of transatlantic communication and the use of radio telephony between ships. The production of apparatus for both Army and Navy aircraft was also outlined, the essential features of which were the design of light and compact sets.

Mining Engineers Adopt a New Name

FROM the beginning to the end, the attendance and enthusiasm of the 119th meeting of the American Institute of Mining Engineers, which was held in New York, February 17 to 20, surpassed all expectations. Besides the ten technical sessions, one of which was in conjunction with the American Institute of Electrical Engineers and one a session of the National Research Council, there were two memorial meetings, one for Dr. Rossiter W. Raymond, for twenty-seven years secretary of the Mining Engineers, and one for the members who had died in service. Two joint sessions with the Canadian Mining Institute, and a meeting devoted to pictures of copper mining, milling, and smelting were also held.

One of the most important events in the history of the Institute took place at the annual business meeting on February 18, when the Institute voted to change its name from the American Institute of Mining Engineers to the American Institute of Mining and Metallurgical Engineers.

It is the consensus of opinion that this marks an epoch in the history and usefulness of this Institute, and it is expected that the change will presage a large and healthy growth in metallurgical fields. Many metallurgists who knew nothing about mining were loath to join a society of mining engineers, despite the fact that over 35 per cent of the papers published in its transactions during the past five years dealt with metallurgical subjects. Additional appropriateness in the new name lies in the fact that the American Institute of Metals is now an important part of the larger organization.

The choice of the name has the double advantage, much to be desired, of retaining the word Engineers and maintaining the former initials of the Institute, A. I. M. E.

At this session the announcement was also made of the election of Horace V. Winchell, Minneapolis, as president.

Technical Sessions

The technical sessions covered a wide field of engineering, and in the Engineering Survey Section will be found abstracts

of some of the more important papers which were presented. The sessions were devoted to problems of industrial organization, the Institute of Metals Division, and to petroleum and gas. Among the special features of these sessions were the topical discussions on housing and Americanization. Americanization, too, was the topic for discussion by the Woman's Auxiliary on Wednesday morning.

Canadian Mining Institute Day

On Tuesday, nearly 100 members of the Canadian Mining Institute were present to discuss the possibility of bringing about uniform mining laws for the United States, Canada, and Mexico, to obviate the maintaining of separate legal departments and managerial forces for the several countries; and to avoid the confusion which, it is said, has led to duplication of effort and has sometimes created a barrier to international coöperation.

Four joint discussions formed the program of the sessions with the Canadian Mining Institute. T. W. Gibson, the representative of the Canadian Mining Institute, opened the discussion on the subject of Principles of Mine Taxation, in which the American Institute was represented by Ralph Arnold, of the United States Treasury Department. Later, Alfred G. Heggem, of Tulsa, Okla., cited an instance in which a high rate of taxation decreased the Government's revenue by retarding the transfer of property. The second discussion of the morning was on the subject of Industry, Democracy, and Education. C. V. Corless represented the visitors and President Jennings the A. I. M. E.

In the afternoon, Mr. T. A. Rickard, of San Francisco, Cal., opened the discussion by a paper entitled The English-Speaking People. He was followed by Dr. A. R. Ledoux, of New York, who gave a brief talk on International Coöperation. In it he spoke of the necessity of closer coöperation, also, with Mexico. President Jennings later said that he is planning a trip to Mexico, when he expects to meet with the Local Section in Mexico, and hopes to initiate some discussion of problems that confront the American engineer. The question of a uniform mining law for North America provoked considerable discussion. While most of the talk was confined to the various Canadian laws, the possibilities of uniform laws with Mexico and Central America were also considered.

Wednesday was devoted to the work of the National Research Council, which occupied the entire day and not only the morning as was planned, to the problems of mining, milling, and geology, and to the study of welding problems, jointly with the American Institute of Electrical Engineers. In all cases the discussion was most animated.

Work of Bureau of Standards in 1918

In the recently issued annual report of the Director of the Bureau of Standards, it is stated that during the fiscal year ended June 30, 1918, the Bureau studied many interesting applications of science to warfare, such as methods for locating enemy batteries; development of new materials, appliances, and methods; and other technical researches of military problems.

The regular work of the Bureau, however, yielded interesting and important results. Apart from new researches, a large volume of testing was completed. The construction of the new industrial laboratory, the completion of the metallurgical laboratory, and the building of a number of emergency war laboratories for airplane investigators were events of interest and will be of great value in the development of the several branches of technology within the activities of the Bureau.

Congress has authorized the establishment of a Government coal yard, or yards, in the District of Columbia, from which all federal buildings will be supplied; this yard will be placed under the supervision of the Bureau.

Apart from confidential reports, the Bureau published during the year about 50 new publications, including scientific and technologic papers, circulars, and bulletins.

Altogether the report of the Director shows an extremely wide range of industrial-research problems in progress, which will be of material aid in readjusting industry to peace conditions.

ROLL OF HONOR

DIED IN THE SERVICE

Hoskins, Stephen Paul, Lieutenant, Co. L, 319th Infantry, American Expeditionary Forces, France.

Lynch, Thomas M., Major, General Supplies Division, Quartermaster Corps, U. S. Army.

Seed, Chas. R., Lieutenant, U. S. Naval Reserve Force.

The following list of names of members in the Service has been compiled during the last two months. It contains, in many cases, names of members who are now discharged from the Service but of whose connection with Army or Navy there has been no previous mention.

Armacost, W. H., Second Lieutenant, Refrigerating Plant Co. 501, American Expeditionary Forces, France.

Auerswald, H. R., First Lieutenant, Chemical Warfare Service, U. S. Army.

Baldwin, C. M., Lieutenant, U S. Naval Reserve Force.

Barry, Ralph, E., Lieutenant, U. S. Naval Reserve Force; Line detailed to Construction, Philadelphia Navy Yard.

Blank, B., Private, First Class, Co. D, 309th Infantry, 78th Division, U. S. Army.

Bunker, A. H., Lieutenant (junior grade), Aviation, U. S. Navy.

Buzby, Paul M., First Lieutenant, Ordnance Department, U. S. Army.

Carlson, C. A., First Class Private, 20th Company, Artillery, U. S. Army.

Cartwell, N. M., Chief Machinist's Mate, U. S. Naval Reserve Force, U. S. Navy Steam Engineering School.

Danks, R. L., Chief Petty Officer, Machinist Division, U. S. Naval Reserve Force.

Flickinger, H. W., Captain, Division of Military Aeronautics, Air Service, U. S. Army.

Goedkoop, Walter C., Corporal, Co. I, 2d Pioneers' Infantry, American Expeditionary Forces, France.

Goezenberger, R. L., Captain, Ordnance Department, American Expeditionary Forces, France.

Goodwin, Guy L., Second Lieutenant, Coast Artillery Reserve Corps, U. S. Army.

Graesser, C. F., Electrician, First Class, Communication Service, U. S. Navy.

Haasis, P. W., Flying Cadet, Squadron 65, S. M. A., Aviation Barracks, Berkeley, Cal.

Harris, W. A., First Lieutenant, Coast Artillery Reserve Corps, U. S. Army.

Hess, A. McD., Ensign, U. S. Navy.

Higley, F. R., Lieutenant, The Infantry School of Arms, Camp Banning, Columbus, Ga.

Igleheart, G. P., Ensign, U. S. Navy.

Johnson, H. S., Captain, 26th Artillery, Coast Artillery Corps, U. S. Army.

Kuttner, J., Warrant Machinist, U. S. Naval Reserve Force.

Macy, R. G., Lieutenant, Ordnance Department, U. S. Army; assigned to Sandy Hook Proving Ground, Sandy Hook, N. J.

Masser, Harry L., Ensign, U. S. Navy.

Nelson, J. E., Ensign, U. S. Navy.

Purinton, J. W., First Lieutenant, Ordnance Department, U. S. Army.

Rahner, Maxwell L., Corporal, Meteorological Section, American Expeditionary Forces, France.

Ralph, J. J., Lieutenant, Purchase, Storage and Traffic Division, General Staff, U. S. Army.

Ranton, J. L., Captain, Co. G, 1st Hawaiian Infantry, U. S. Army; stationed at Schofield Barracks, Hawaiian Territory.

Root, F. J., Major, Inspection Division, Ordnance Department, U. S. Army.

Smith, P. M., Second Lieutenant, 1st Co., Rep. Dep. Battalion, Signal Corps, American Expeditionary Forces, France.

Snyder, C. L., Second Lieutenant, Nitrate Division, Ordnance Department, U. S. Army.

Sparks, H. C., D.S.O., M.C., Colonel, 3d Army Labour Commandant, British Expeditionary Force, France.

Thee, W. C., Captain, Coast Artillery Corps, American Expeditionary Forces, France.

Uehling, E., Second Lieutenant, 6th Anti-Aircraft Machine Gun Battalion, U. S. Army.

Wilson, Leroy A., First Lieutenant, Air Service, Aeronautics, U. S. Army.

Windle, A. E., Second Lieutenant, Air Service, American Expeditionary Forces, France.

Woodbury, J. G., Major, Production Division, Ordnance Department, U. S. Army.

Woolner, S. A., Second Lieutenant, Air Service, Aircraft Production, U. S. Army.

NECROLOGY

J. SELLERS BANCROFT

J. Sellers Bancroft, a member of the Society since 1880, manager from 1909 to 1911, and vice-president from 1915 to 1917, died at his home in Philadelphia on January 29 after an illness of several months.

Mr. Bancroft was born in Providence, R. I., on September 12, 1843. His father, Edward Bancroft, a distinguished engineer, who made many inventions of machine tools and shafting appliances, founded the firm of Bancroft and Sellers, now Wm. Sellers & Co., Inc., Philadelphia. As a sidelight on the growth of the machine-tool industry in this country, it is interesting to note that Edward Bancroft built the first metal planer in the United States, the bed and table being chipped and filed by hand.

J. Sellers Bancroft was educated in Philadelphia, being graduated from the high school of that city in 1861. In February of that year he entered the employ of Wm. Sellers & Co., being apprenticed to his uncle, Wm. Sellers. In 1863, at the age of twenty, he was made gang foreman, and in 1866 general foreman. He was admitted to the firm in 1873, and when the business was incorporated in 1887 he was made general manager.

While with the Sellers Co. he was granted many patents on machine tools, injectors, shafting appliances, power cranes and their interlocking electrical devices.

For forty-one years he remained with this company, leaving in 1902 at the age of fifty-nine to become general manager and mechanical engineer of the Lanston Monotype Machine Co., Philadelphia. In the following sixteen years of his life he did his greatest engineering work; the perfection of the monotype and the special machines for making the molds and matrices used with it for casting and composing type in automatically justified lines. The organization of the monotype factory exemplifies his work as an executive and a leader of men.

A keen lover of books, it was a great joy to him that his work did much to raise the quality and reduce the cost of printing not only in the United States, but also throughout the world.

At the time of his death he was vice-president and treasurer of the Monotype Co., as well as its general manager and mechanical engineer.

More than 100 patents testify to the scope of Mr. Bancroft's engineering work and the range of his creative ability. To those who worked with him on the solution of any of the many problems that engaged his attention, his thoroughness, the result of his never-failing perseverance and patience will be an ever-inspiring memory.

J. SELLERS BANCROFT

GEORGE URQHART BORDE

George U. Borde, consulting engineer, died in New Orleans, La., on December 17, 1918. He was born in January 1871 in New Orleans and was graduated from Tulane University in 1888. Mr. Borde was formerly district engineer for the southern district of the Edison General Electric Co. After a short period in the contracting business in Memphis, he opened consulting offices in New Orleans, which he still maintained at the time of his death. He became a member of the Society in 1908.

Mr. Borde, at the time of his death, was one of the most prominent consulting engineers in the City of New Orleans. He was retained as consulting engineer by the Great Southern Lumber Co. and also by the United States Industrial Alcohol Co. In connection with his work for the latter, his investigations in regard to the process of the manufacture of ethol alcohol from wood waste was possibly his most important work.

GEORGE K. GARVIN

George K. Garvin, president of the Garvin Machine Co., New York, died at his home in Garden City, Long Island, on February 20, 1919. Mr. Garvin was born on May 2, 1859, in Hartford, Conn. He was educated in the public schools of New York and Jersey City, later attending Hasbrouck Institute. At the age of sixteen he entered his father's business, then known as Smith & Garvin, and upon his father's death became president of the concern. He became a member of the Society in 1909.

WALTER V. TURNER

Walter V. Turner, manager of engineering of the Westinghouse Air Brake Co., died at the Columbia Hospital, Wilkinsburg, Pa., January 9. Mr. Turner was born in Epping Forest, Essex, England, in 1866, and was educated in the Textile Technical School of Yorkshire. He came to this country in 1888 and settled in the West, where he became the manager of a sheep and cattle company. For several years he was general air-brake inspector for the Atchison, Topeka and Santa Fé Railroad. In 1903 he became connected with the Westinghouse Air Brake Co. as engineer, remaining with that company and associated interests until his death.

Mr. Turner was an inventor of international prominence, patenting more than 400 devices in use on railroads and in industrial plants. For his achievements as an inventor in the development of the air brake, he was awarded the Elliott Cresson and the Edward Longstreth medals by The Franklin Institute of Philadelphia. In May 1918 the University of Pittsburgh conferred the degree of Doctor of Engineering upon him. He became a member of the Society in 1913.

CHARLES EDWARD JOHNSON

Charles E. Johnson, chief engineer of the Diamond Gasoline Co., Kansas City, Mo., died on January 5, 1919. He was born in December 1883 in East Atchison, Mo., and was a 1910 graduate of the University of Kansas. Mr. Johnson was formerly connected with the Santa Fe Railway Co. as draftsman and with the Lawrence Paper Mill, Lawrence, Kan., as chief engineer. He had also held the position of instructor in mechanical drawing in the high schools of Kansas City and Ottawa, Kan. He became an associate-member of the Society in 1918.

THOMAS M. LYNCH

Thomas M. Lynch, Major, General Supplies Division, Quartermaster Corps, U. S. Army, died on December 18, 1918. He was born on July 2, 1882, in Worcester, Mass., and attended the Worcester Polytechnic Institute. Major Lynch had formerly been connected with the Buena Vista Extract Co., as superintendent, and was also for two years staff member of the J. J. Lynch Co., New York. At the time of his death, Major Lynch was Chief of the Administrative Branch of the General Supplies Division, Quartermaster Corps, having been placed in charge of that department at the time of its creation. He organized this whole division and received his appointment as Major in recognition of his merit and the efficient results he had secured. Major Lynch became an associate-member of the Society in 1914.

HENRY GEORGE PULSCHEN

Henry G. Pulschen, of the inspection department of the J. G. White Engineering Corporation, New York, died on December 24, 1918. Mr. Pulschen was born in February 1891 in New York City and was a graduate of Cooper Union and of Pratt Institute. He had formerly been associated with the H. R. Worthington Co. as detailer on power-plant machinery and as designer and checker with the Alberger Pump & Condenser Co. Mr. Pulschen became a junior member of the Society in 1918.

HENRI LEAUTE

[News of the death of Henri Léauté, a distinguished Honorary Member of this Society, was received some time ago, but owing to war conditions it has not been possible to secure data for a suitable memorial notice until quite recently.—Editor.]

Henri Léauté, the great French engineer and mathematician, was born in 1847. In 1866, at the age of 19, he had the unique distinction of being accepted at the head of a long list of competitors for entrance into two of the best technical schools in France, the Ecole Polytechnique and Ecole Normale. He entered the latter and was graduated in 1869 with the degree of engineer.

The war of 1870 naturally interrupted his professional career, but, released from military service in 1871, the young man at once engaged in three lines of work requiring very dissimilar characteristics of mind

Henry Léauté

—those of medicine, mathematics and mechanics, and rapidly established an important position for himself in each of these branches of science.

The first paper published by Léauté dealt with partial derivative equations of the first order. Of much greater importance was the second paper, dealing with friction in bearings. Other of his works covered the subjects of general kinematics, strength of materials, dynamics and theory of machines. In all of this work he made extensive use of higher mathematical methods in the solution of mechanical problems. It is significant, however, that in all his work he carefully avoided the use of mathematics for its own sake and never lost sight of the practical applications of his investigations.

In kinematics, Léauté introduced a new conception, namely, the order of proximity of two arcs of neighboring curves. Because of this concept he was enabled to formulate precise mathematical rules to take the place of former approximations, and these he applied in the design of gears and in the improvement of Watt's parallelogram and the Farcot governor.

In the field of the strength of materials, Léauté developed important data in relation to the elastic deformation of circular members and the distribution of stresses in cylindrical bands, especially in band brakes. Of the greatest importance, however, were his master papers dealing with dynamics and the theory of machines. His treatise on Teledynamic Transmission has become a classic. The transmission of power at a distance by means of cables was fully solved by him, both from the theoretical and practical points of view. The great importance of this work has failed to be realized only because the introduction of electric transmission has materially reduced the field of application of cable transmission.

The governing of engines formed the subject of several papers of great importance. Starting with the study of flyball governor, he gradually passed to that of oscillations having long periods and investigated the whole field, applying new and ingenious mathematical methods.

In addition to his scientific work, Léauté took a prominent part in national educational activties, and also in business, where he held important positions, such as that of president of the French Telephone Company and also of the Paris Electric Distribution Company.

In 1891 he was elected honorary member of The American Society of Mechanical Engineers. In 1915, notwithstanding a malignant disease which for years had sapped his strength, he took an active part in the management of war industries, on the running of which depended the defense of the country at that time. It is no exaggeration to say that this patriotic activity was the prime cause of his death.

ALFRED H. RAYNAL

Alfred H. Raynal, member of the Society since 1884 and manager from 1889 to 1902, died at his home in Washington, D. C., on March 1. Mr. Raynal was born on August 5, 1848, in Hamburg, Germany, serving his apprenticeship as mechanic and draftsman in a marine-engineering establishment there. In May 1862 he came to the United States and worked as a machinist and draftsman for private concerns in New York. In 1863 he was engaged by the Navy Department as draftsman on the design of twenty light-draft monitors. In 1864 he made the drawings for and superintended the construction of the monitor *Squando* at the works of McKay Aldus at East Boston, Mass.

He next entered the employ of the Babcock & Wilcox Co., Providence, R. I., working out details of their engine and boiler which latter is now used so extensively in the U. S. Navy. In 1870 Mr. Raynal became superintendent of the works of Poole & Hunt, Baltimore, who were building engines and boilers under the Babcock & Wilcox patents. From 1880 to 1884 he was superintendent of the Wheelock Engine Works, Worcester, Mass. He was next connected with the DeLamater Iron Works, New York, as superintendent, where he did considerable work for Capt. John Ericsson, building his submarine gun, high-expansion engine, sun motor, etc. In recognition of his services to him, Captain Ericsson presented Mr. Raynal with a rare and valuable book on his inventions. This book was presented to the Society by Mr. Raynal for record.

From 1890 to 1897 he successively held the following positions: Superintendent of the Richmond Locomotive Works, building the machinery of the U. S. battleship *Texas;* superintendent of Samuel Moore & Son's Shipyard, Elizabeth, N. J., building the revenue steamer *Maple* and the practice cruiser *Bancroft;* superintendent of the Corliss Engine Co., Providence, R. I.; superintendent of the Walker Co., Cleveland, Ohio. In 1897 Mr. Raynal studied patent law, working in an attorney's office in Cleveland.

In 1898, during the Spanish War, at the personal request of Admiral Melville, he entered the Navy Department as draftsman to design engines for the first sixteen torpedo-boat destroyers, as his experience in building successfully the spider-frame high-speed engines of the *Bancroft* had been unusually valuable.

From that time Mr. Raynal's work was in the Navy Department where he was of signal service in the Bureau of Steam Engineering. Mr. Raynal acted as expert engineer in the courts in suits resulting from explosions of boilers, bursting of flywheels, etc., and in admiralty cases.

He was a member of the American Society of Naval Engineers and Marine Architects, the American Society of Naval Engineers, the Washington Society of Engineers, and the American Society of Marine Draftsmen.

CHARLES R. SEED

Charles R. Seed, for the last seven years chief engineer of the Worcester Electric Light Co. and recently lieutenant in the United States Naval Reserve Force, died in Worcester on October 8, 1918, of pneumonia. Mr. Seed was born in April 1876 in Lawrence, Mass., and was educated in the schools of that city, later receiving training aboard the Massachusetts Nautical Schoolship *Enterprise*, for seven years serving as engineer on runs between Europe and America. When the United States declared war against Germany he offered his services, was commissioned ensign and assigned to overseas patrol duty in the war zone, later being promoted to lieutenant. He had formerly served as chief engineer with the Blackstone Manufacturing Co., Blackstone, Mass., and as superintendent of power with the Rockingham County Light & Power Co., Portsmouth, N. H. Mr. Seed became an associate-member of the Society in 1914.

ROY BROOKS SMITH

Roy Brooks Smith, assistant electrical engineer Pennsylvania Lines West, died on October 19, 1918. He was born in Uhrichsville, Ohio, in March, 1882. In 1904 he received his M. E. degree from Ohio State University, serving his apprenticeship during his vacations with the Pennsylvania Lines West. Upon graduation he became connected with the same company as assistant engine-house foreman. He was rapidly promoted to more responsible positions, and just previous to his death was made assistant electrical engineer. He became a junior member of the Society in 1905 and was promoted to full membership in 1912.

HENRY DREW EGBERT

It is with deep regret that we announce the death of the Secretary of our New York Section Committee, Henry Drew Egbert. Mr. Egbert died on Sunday, March 23, in his 33d year. A more extended notice will appear in an early issue of Mechanical Engineering.

PERSONALS

In these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary, and items should be received by March 15 in order to appear in the April issue.

CHANGES OF POSITION

G. H. COOPER, formerly secretary and treasurer of the Electric Company, Hartford, Conn., has become identified with the H. T. Paiste Company, Philadelphia, Pa., in the capacity of mechanical superintendent.

CHESTER H. MANNION, until recently chief engineer, Kerr Mills, American Thread Company, Fall River, Mass., has entered the employ of the Nashua Manufacturing Company, Nashua, N. H., in charge of their steam plant.

ROBERT D. KOPLIN has left the employ of the Air Nitrates Corporation Agents of the U. S. Ordnance Department, to accept a position in the office of the chief engineer of construction of the Weirton Steel Company, Weirton, W. Va.

W. HARWELL ALLEN has assumed the duties of secretary and assistant manager of the Memphis Heating Company, Memphis, Tenn. He was until recently associated with the J. G. White Engineering Corporation, Sheffield, Ala.

JOHN FISHER, formerly chief engineer, Hartford district, of The Connecticut Company, Hartford, Conn., has accepted the position of chief engineer of the Quincy Point Power Station of the Bay State Street Railway Company, Quincy, Mass.

L. F. MERRITT has severed his connections with the Bureau of Aircraft Production and has become associated with Joseph N. Smith and Company, of Detroit, Mich., as mechanical engineer.

E. T. KOSKINEN, formerly affiliated with the Nordberg Manufacturing Company, Milwaukee, Wis., as draftsman, has become connected with the machinery division of the Newport News Shipbuilding and Dry Dock Company, Newport News, Va.

ROBERT W. SCHUETTE, recently mechanical engineer with the Mesta Machine Company, Pittsburgh, Pa., has become affiliated with the Harrisburg Pipe and Pipe Bending Company, Harrisburg, Pa.

WILLIAM E. A. WALTHER has become associated with the United Glass Bottle Manufacturers, of London, England. He was formerly in the service of the Illinois Glass Company, Alton, Ill., in the capacity of mechanical engineer.

NORMAN G. HARDY has assumed the position of chief mechanical and electrical engineer for the Arizona Copper Company Ltd., Clifton, Ariz. He was formerly associated with the Old Hickory Powder Plant, Jacksonville, Tenn.

MATHER W. SHERWOOD has left the employ of the Burke Electric Company and has entered the service of the Ball Engine Company, of Erie, Pa.

LOUIS MARDAGA has assumed the duties of sales engineer for the Mickle Milnor Engineering Company, Philadelphia. He was until recently assistant naval inspector of Ordnance, Alloy Steel Forging Plant, Carnegie, Pa.

RALPH C. CHESNUTT, formerly with the Willys-Overland Company, Toledo, Ohio, is now assistant chief engineer for the North American Motors Company, Pottstown, Pa.

C. L. HORNE, formerly mechanical engineer with the Underfeed Stoker Company, Chicago, Ill., has become associated with The Texas Company, Roanoke, Va., in the capacity of lubricating engineer.

GEORGE A. HICKERSON has resigned his position as a mechanical appraiser with Ford, Bacon and Davis, New York, to accept a position as chief engineer with the Rhodia Chemical Company, New Brunswick, N. J.

HOWARD M. GROFF has assumed the duties of chief engineer of factories for Robert H. Ingersoll and Brother, of New York. He was recently affiliated with the Frankford Arsenal, Philadelphia, Pa., as gage expert.

CHARLES E. BECK, formerly sales engineer with Baker-Dunbar-Allen Company, Cleveland, Ohio, has accepted a similar position with the Busch-Sulzer Bros.-Diesel Engine Company, St. Louis, Mo.

J. A. POLSON, professor of mechanical engineering at the Michigan Agricultural College, East Lansing, Mich., has resigned to accept a position of factory manager with the Milwaukee Stamping Company, of Milwaukee, Wis.

ANNOUNCEMENTS

RAY B. WHITMAN, formerly with the Emergency Fleet Corporation at Cleveland, is now inspecting the construction and machinery installation of steel river paddle steamers and barges for the Dravo Contracting Company of Pittsburgh, Pa.

V. L. SANDERSON has had supervision of the Philadelphia district of the Terry Steam Turbine Company since the death of Charles E. Hague in April 1917.

E. D. LATTER is a member of the firm of Harris, Latter and Company, New York, which has recently been formed to conduct business as constructive accountants and auditors.

JOHN E. MUHLFELD has assumed the presidency of the Pulverized Fuel Equipment Corporation, which has recently been organized for the purpose of taking over the business of the Locomotive Pulverized Fuel Company. MR. H. F. BALL is Vice-President Executive, and V. Z. CARACRISTI is Vice-President in charge of engineering, of the company.

FREDERICK A. WALDRON, consulting engineer, announces that in addition to his consulting practice he has established a bureau for audit and inspection of organizations and factory methods. The object of this bureau is to provide periodical reports for boards of directors or the officials of corporations as to the efficiency of the operating and producing factors of their organizations. The services of this Bureau will also be available for consultation relative to the formation of new organizations and industrial enterprises.

PROF. W. H. KENERSON, of Brown University, is now in France organizing instruction in mechanical engineering in the Army of Occupation, and is a member of the committee secured by the Y. M. C. A. to advise the Army authorities there in these matters.

R. W. BAILY has accepted the position of assistant general manager of the Jacksonville Dry Dock and Repair Company, Jacksonville, Fla.

LIEUT. A. G. KESSLER, U. S. N. R. F., who for six months past has been in charge of the Gun Division of the Bureau of Ordnance, Navy Department, has been released from active duty in the Naval Service and has become vice-president of the General Ordnance Company, Derby, Conn., and of the National Tractor Company, Cedar Rapids, Ia., in charge of purchasing and production at both plants. Mr. Kessler was formerly general manager of the Lakeside Forge Company, Erie, Pa.

CALVIN L. HALLADAY has become affiliated with the Jackson Motor and Manufacturing Company, Jackson, Mich.

LIEUT. R. K. MACMASTER and LIEUT. GEORGE S. VAN GELDER, of the Ordnance Department Claims Board, will resume their work in the field of production and cost accounting under the firm name of MacVan Engineering Company, with offices at 50 East 42d Street, New York.

CHARLES PIEZ, director general of the Emergency Fleet Corporation, will resign his position, effective May 1, to return to Chicago to resume the presidency of the Link-Belt Company.

T. E. BUTTERFIELD, associate professor of mechanical engineering at Lehigh University, is back after service on the teaching staff of the Post Artillery School at Fort Monroe, Va., where he held the rank of Major.

HUNTLY H. GILBERT, who left the service of the Pressed Steel Car Company and the Western Steel Car and Foundry Company at the beginning of the war to enter the Army as captain in the Ordnance Department at Washington, and later was commissioned major and transferred to the Rock Island Arsenal, has reëntered the service of the above-named companies as assistant manager of sales of the western district, with headquarters in Chicago, Ill.

WILLIAM G. R. BRAEMER has resigned as president of the Braemer Air Conditioning Corporation, Philadelphia, Pa., to open a consulting engineering office in the Stephen Girard Building, Philadelphia. He will specialize in air conditioning and drying and will also act as consulting engineer for the above company.

LIEUTENANT WILLIAM P. HAYES, U. S. N. R. F., at present commanding one of the U. S. men-of-war on the China Station, has been promoted to the rank of Lieutenant Commander.

WILLIAM F. FRANKET has become connected with the Wood-Mosaic Company, Inc., New Albany, Ind., manufacturers of parquetry, hardwood flooring, veneers and lumber, as manager of the timber department.

APPOINTMENTS

CHESTER W. WILSON, formerly engineer of the Garfield Smelting Company, has been transferred to El Paso, Tex., and appointed chief engineer of the Mexican Department of the American Smelting and Refining Company.

LIBRARY NOTES AND BOOK REVIEWS

GRAPHICAL AND MECHANICAL COMPUTATION. By Joseph Lipka, Ph.D. John Wiley & Sons, Inc., New York, 1918. Cloth, 6 x 9 in., 264 pp., 205 figures, 2 folding charts, $4.

This book presents a systematic development of the construction of alignment charts, the value of which in facilitating computation is very generally recognized by engineers. The mathematical treatment employed is simple and the methods are abundantly illustrated by charts for many important engineering formulæ.

Many engineering and scientific formulæ are empirical, and the value of many investigations is much enhanced by the discovery of the laws connecting the results obtained. One chapter of the book deals with the fitting of equations to experimental data, and another considers the case where the data involved are periodic, as in alternating currents, sound waves, etc., and gives numerical, graphical and mechanical methods for determining the constants of the equation. When empirical formulæ cannot be fitted to the data available, the latter may still be efficiently handled for purposes of further computation by the methods for interpolation, differentiation and integration developed in the closing chapters.

The book embodies a course that has been given by the author for a number of years at the Massachusetts Institute of Technology.

THE ELEMENTS OF WOODEN SHIP CONSTRUCTION. By W. H. Curtis. First edition. McGraw-Hill Book Co., Inc., New York, 1919. Cloth, 6 x 9 in., 223 pp., 199 illus., $2.50.

A revised and enlarged edition of a course prepared for the education and training section of the Emergency Fleet Corporation. It is intended for the use of carpenters and others, who, though skilled in their work, lack the detailed knowledge of shipbuilding necessary for efficiency.

FIGHTING THE BOCHE UNDERGROUND. By H. D. Trounce. Charles Scribner's Sons, New York, 1918. One-quarter cloth, 5 x 8 in., 234 pp., 7 pl., 1 por., 1 diag., $1.50.

Captain Trounce, an American mining engineer, enlisted in the Royal Engineers in 1915, and transferred to the Engineers' Reserve Corps of the American Army in 1917. His book is a description of the underground fighting in which he participated in Flanders, at Arras, Vimy Ridge and elsewhere.

INDUSTRY AND HUMANITY. A Study in the Principles Underlying Industrial Reconstruction. By W. L. Mackenzie King. Houghton Mifflin Co., Boston and New York, 1918. Cloth, 6 x 8 in., 567 pp., 10 charts, $3.

This volume by the former Minister of Labor of Canada is a statement of the underlying principles which are finding expression in the organization of industrial society and which should obtain in all efforts at reconstruction. The book is based on the author's twenty years of personal contact with labor problems, supplemented by a study of the literature on the subject.

INSTINCTS IN INDUSTRY. A Study of Working-Class Psychology. By Ordway Tead. Houghton Mifflin Co., Boston and New York. 1918. Cloth, 5 x 8 in., 222 pp., $1.40.

With the idea of contributing to a better understanding of people in their capacity as manual workers, Mr. Tead has analyzed in turn the ten basic instincts on which our life and conduct rest, has shown how each affects the worker's relation to his job, and how each must be studied and used in the task of attaining sound relations between the employer and the employed.

THE INSTRUCTOR, THE MAN AND THE JOB. A Handbook for Instructors of Industrial and Vocational Subjects. By Charles R. Allen. J. B. Lippincott Co., Philadelphia (copyright 1919). Cloth, 5 x 8 in., 373 pp., $1.50.

The author, who has been agent for industrial training for the Massachusetts Board of Education and superintendent of instructor training for the Emergency Fleet Corporation, gives the result of his experience in this volume, which is intended as a handbook for instructors in industrial plants and as instruction notes in training courses for instructors.

JOHNSON'S MATERIALS OF CONSTRUCTION. Rewritten by M. O. Withey and James Aston. Edited by F. E. Turneaure. Fifth edition. John Wiley & Sons, Inc., New York, 1919. Cloth, 6 x 9 in., 840 pp., illus., 1 pl., 1 por., tables, $6.

As the progress of the last twenty years in the knowledge of the properties of materials made Professor Johnson's book an inadequate account of the subject, it has been rewritten under the editorship of his successor at the University of Wisconsin.

The authors have aimed to retain the broad scope of the original work as a statement of the essential information concerning the sources, manufacture or fabrication of the principal materials, their important mechanical and physical properties and the influence of various factors upon them, the causes of defects and variations, the methods of testing and their general uses. The arrangement of the book is new and some changes have been made in its scope. Obsolete matter has been eliminated and modern data substituted. The volume is intended to serve both as a textbook and as a work of reference.

1919 RECORD OF AMERICAN AND FOREIGN SHIPPING, NEW YORK. Published by the American Bureau of Shipping, "American Lloyds." New York, 1919. Morocco, 10 x 10 in., 1056 pp.

The 1919 Record presents no change in form from previous years. It provides a record of American and foreign vessels, classified according to the rules of the Bureau, and is endorsed by the Navy Department and the boards of marine underwriters of New York, Boston and San Francisco. In addition to the list of vessels, there are lists of owners, marine underwriters' representatives, surveyors, machinery constructors, dry docks, marine railways, and ship builders. An index of changed names is also included.

OUR NATIONAL FORESTS. A Short Popular Account of the Work of the United States Forest Service on the National Forests. By Richard H. Douai Boerker. The Macmillan Co., New York, 1919. Cloth, 5 x 8 in., 238 pp., 80 illus., $2.50.

The author presents a well-illustrated account of our national forest problem and of the work of the Forest Service. Written in popular form and based largely upon his personal experience and observation.

PETROLEUM REFINED. By Andrew Campbell, with a foreword by Sir Boverton Redwood. Charles Griffin & Co., Ltd., London, 1918. Cloth, 6 x 9 in., 277 pp., 138 illus., 29 folding pl., 3 diag., 11 tables, $8.50.

This volume describes the ordinary methods used to prepare marketable products from petroleum, except "cracking" methods. The work is based on extended practical experience, is well supplied with illustrations and drawings and includes a bibliography.

PHYSICS FOR TECHNICAL STUDENTS. SOUND, LIGHT, ELECTRICITY AND MAGNETISM. By William Ballantyne Anderson. First edition. McGraw-Hill Book Co., Inc., New York, 1919. Cloth, 6 x 9 in., 794 pp., 373 illus., $3.

This book completes the author's textbook of physics, the first part of which has been published previously under the title Mechanics and Sound. The writer has aimed to produce a college text especially suitable for students of agriculture and engineering, in which particular attention is directed to practical applications of the subject.

PRACTICAL SHIP PRODUCTION. By A. W. Carmichael. First edition. McGraw-Hill Book Co., Inc., New York, 1919. Cloth, 6 x 9 in., 252 pp., 101 illus., $3.

The purpose of this book is to serve as an introduction to the subject by presenting the most important general principles of ship design and describing the various processes of shipbuilding. The treatment is practical rather than theoretical and matters of construction are more fully considered than problems of design.

The Rudder Directory. A Trade List of Shipbuilding and Marine Industries. Compiled and issued by the Rudder Publishing Co., New York, 1919. Cloth, 6 x 9 in., 332 pp., 1 pl., $5.

Included in this directory are lists of the steel, wood, composite and concrete shipyards, with the names of their officers, ship and engine repair plants, dry docks and marine railways, owners and operating companies, marine insurance companies, boat builders, engine builders, ship chandlers and manufacturers of equipment, parts, etc. A supplement, revised to February 6, 1919, brings the data concerning the U. S. Shipping Board and the Emergency Fleet Corporation up to date.

Thomas' Register of American Manufacturers and First Hands in all Lines. Thomas Publishing Co., New York (copyright 1919). Cloth, 10 x 12 in., 4200 pp., $15.

The tenth edition of this well-known trade directory is dated "October" as usual, although corrections were made up to December 20. The directory is divided into various lists, the chief one being a classified list of manufacturers in all lines, sub-classed geographically and provided with an extensive index to the classification. Other lists are of representative banks, boards of trade, chambers of commerce, etc., trade papers, leading trade names and an alphabetical list of manufacturers. The volume contains 4200 pages of information, conveniently arranged for quick consultation.

The Theory of Electricity. By G. H. Livens. The University Press, Cambridge, England, 1918. Cloth, 11 x 7 in., 717 pp. $8.25. (Gift of G. P. Putnam's Sons.)

Dissatisfaction with the treatment of this subject in standard textbooks, which the author believes to be incomplete, often unconvincing and sometimes erroneous, leads him to offer this work as a general textbook on the mathematical aspects of modern electrical theory in which an attempt is made to present the complete subject in a consistent form. Although his exposition is essentially a mathematical one, much of the purely analytical mathematics usually associated with the subject has been omitted. Particular attention has, however, been given to the rigorous formulation of underlying physical principles and to their translation into a mathematical theory. The dynamical aspects of the subject have been specially emphasized throughout.

Classroom Lecture Notes. Automotive Starting, Lighting and Ignition. By R. C. Fryer. Second Edition. John Wiley and Sons, Inc., New York, 1918. Cloth, 8 x 5 in., 210 pp., diag. $1.25.

The author provides a general, concise series of notes, including the essential knowledge needed by the student, but requiring enlargement by the instructor. Eighty-eight pages of wiring diagrams are given.

Practical Oil Geology. The Application of Geology to Oil-Field Problems. By Dorsey Hager. Third edition. McGraw-Hill Book Co., Inc., New York. 1919. Flexible cloth, 7 x 5 in., 253 pp., 126 illus., 37 tables. $2.50.

The author of this handbook has aimed to provide a clear, concise and practical work on the occurrence of oil and its geology, based on American practice. The present edition, the third since its appearance in 1915, has been thoroughly revised, enlarged and reset.

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